REPORT

COMPLETION REPORT
ST. LAWRENCE RIVER REMEDIATION PROJECT

VOLUME 1 OF 2: 2009 REMEDIAL ACTION

ALCOA

June 2010

DRAFT COMPLETION REPORT

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EXECUTIVE SUMMARY

This *Completion Report* for the St. Lawrence River Remediation Project documents the scope, performance, and results of remediation activities in the St. Lawrence River adjacent to the Alcoa Massena East (formerly Reynolds Metals Company [RMC]) Plant in Massena, New York. This Completion Report addresses remedial work performed in 2001 and 2009 and has been divided into two separate volumes. Volume 1 of 2 summarizes the remedial construction activities conducted in 2001. Volume 2 of 2 describes the follow-up remedial action work completed in 2009 to address residual sediments of concern remaining after the 2001 work. The 2001 and 2009 activities were conducted pursuant to a 1989 Unilateral Administrative (CERCLA 106) Order, a 1993 Record of Decision (ROD), a1998 Decision Document Amendment, and a 2008 Explanation of Significant Difference (ESD) issued by the U.S. Environmental Protection Agency (USEPA) that required remediation of sediments in the river north of the RMC facility.

Major components of the remedial action at the site specified in the 1993 ROD included the following:

- Dredging and/or excavation of an estimated 51,500 cubic yards (yd^3) of sediments with polychlorinated biphenyl (PCB) concentrations above 1 part per million (ppm), total polycyclic aromatic hydrocarbon (PAH) concentrations above 10 ppm, and total dibenzofuran concentrations above 1 part per billion (ppb) from areas in the St. Lawrence River and the associated river bank.
- Thermal desorption treatment of an estimated 14,500 yd^3 of dredged/excavated material with PCB concentrations above 25 ppm. Desorbed contaminants recovered during thermal desorption were to be sent to an off-site permitted commercial incinerator. Untreated, dewatered sediments with PCB concentrations between 1 ppm and 25 ppm and treatment residuals (which were expected to have PCB concentrations below 10 ppm) were to be disposed of on site in the Black Mud Pond. The Black Mud Pond was to be capped in conformance with the requirements of a ROD issued on January 22, 1992 by New York State Department of Environmental Conservation (NYSDEC) for the land-based cleanup at the RMC facility.

In September 1998, USEPA modified the ROD by issuing a Decision Document Amendment (ROD Amendment) that changed several key components of the remedy dealing with the disposal of dredged sediment. The ROD Amendment specified the following changes to the 1993 ROD:

- Elimination of the on-site thermal desorption treatment component of the remedy
- Landfilling of all dredged and dewatered sediments with concentrations of PCB between 50 and 500 ppm at an approved, off-site facility
- Treatment of all dredged and dewatered sediments with PCB concentrations exceeding 500 ppm.
- Consolidation of all dredged and dewatered sediment with PCB concentrations less than 50 ppm in the on-site Industrial Landfill, which was to be capped in compliance with NYSDEC's 1992 ROD and 1993 Consent Order for the land-based cleanup at the RMC facility.

Volume 1 of this Completion Report describes the 2001 remedial construction activities that were conducted to fulfill the requirements of the 1993 ROD and the 1998 ROD Amendment. The remediation area was divided into 268 cells within three Evaluation Areas (1, 2, and 3) established for the evaluation of the remediation progress. Specific activities conducted during the 2001 remedial construction included the following:

- Installation of a sheet pile wall around the perimeter of the remediation area.

- Dredging of approximately 86,000 yd^3 (ex-situ) of sediment from the 268 cells within the sheet pile enclosure. Dredging was performed using three derrick barges equipped with Cable Arm environmental clamshell buckets and alternative dredging methods including the use of a rock bucket and hydraulic clamshell.
- Disposal of the dredged sediments consistent with the requirements of the 1998 ROD Amendment. Approximately 69,000 cy of dredged sediment with <50 ppm PCBs were brought to the on-site landfill. A total of 22,356 tons of sediment with ≥50 ppm PCBs was shipped to an off-site disposal facility after being stabilized with Portland cement.
- Placement of an interim cap over 15 cells due to persistent residual post-dredging PCB levels above the site clean-up goals in 12 of these cells. The three additional cells were capped due to their close proximity to the targeted 12 cells.
- Environmental monitoring conducted throughout the 2001 construction. The monitoring showed that there were no adverse impacts to human health or the environment as a result of the remediation activities.
- Implementation of a comprehensive community and worker safety program. The 2001 remedial action was completed safely with site workers logging nearly a half million hours without a lost-time accident.

As noted above, post-dredge verification sampling indicated that residual sediments with PCB concentrations above remedial action levels remained in some of the dredging cells. Since additional dredging to remove the residuals was ineffective, an interim cap was placed at the end of the 2001 construction season. Completion of the interim cap for the residual PCB contamination was originally planned for 2002, but was postponed due to USEPA's concerns regarding residual PAH contamination detected in post-dredge sediment samples.

Alcoa and USEPA ultimately entered into a dialogue on the appropriate scope of work for completion of the interim PCB cap and options to address residual PAH-impacted sediments at the St. Lawrence River site. These interactions prompted several auxiliary tasks, including additional sediment sampling efforts, a comparative evaluation of alternatives, an assessment of PAH toxicity and bioavailability in the remaining sediments, and a detailed PAH cap design analyses. This information collectively was used to inform appropriate follow-up remedial actions to the 2001 work. Final remedial actions for the Site were formalized in an ESD document, which was issued by USEPA in December 2008 (USEPA 2008).

In accordance with the 2008 ESD, additional remedial action work was performed at the site in 2009 to address residual sediments of concern remaining after the 2001 work. The approved scope of work for completion of the St. Lawrence River Remediation Project in 2009 consisted of the following items:

- Provisions for water quality containment systems to enclose the work areas.
- Nearshore excavation in a portion of four cells to address residual contaminant concentrations, to the extent technically feasible, while providing sufficient depth to install a non-emergent cap following capping.
- Transport, dewatering and/or stabilization, and disposal of excavated sediments at an approved off-site disposal facility.
- Completion of the 2001 interim PCB cap in 15 cells.
- Construction of a subaqueous cap in 53 cells to address remaining PAH-impacted sediments utilizing the approved PAH cap design.

- Placing a habitat layer over the completed PAH and PCB cap areas.
- Implementation of an environmental monitoring plan prior to and during field activities.

Volume 2 of this Completion Report describes the 2009 remedial construction activities that were conducted to fulfill the requirements of the 2008 ESD. Specific activities conducted during the 2009 remedial construction included the following:

- Excavation of approximately 450 yd^3 of sediment from portions of four nearshore cells
- Stabilization and transport of the excavated material to an off-site disposal facility
- Completion of the PCB cap over 15 cells that received an interim cap during the 2001 remedial action. In addition, the PCB cap was placed over three additional nearshore cells that were initially planned to receive the PAH cap.
- Placement of a PAH cap over 50 cells with residual PAH contamination following the 2001 dredging. The variation between the planned number of cells receiving the PAH cap (53) and the actual number of cells receiving the PAH cap (50) was due to the fact that three cells were converted from the PAH cap design to the PCB cap design based on analytical testing results following the near-shore excavation work.
- Placement of a habitat layer over all of the capped cells as specified in the 2008 ESD.
- Restoration of the shoreline area disturbed during the 2001 and 2009 remedial activities.
- Environmental monitoring for surface and drinking water quality and air quality during the 2009 remedial activities. The monitoring showed that there were no exceedances of any corrective action levels throughout the project duration.
- Implementation of a comprehensive community and worker health and safety program. Health and safety efforts were successful during the course of the project; a total of 22,772 man hours were recorded with zero lost work days and zero recordable injuries.

The combined efforts of the 2001 and 2009 remedial construction activities at the St. Lawrence River site have successfully met the requirements of the 1993 ROD, 1998 ROD Amendment, and the 2008 ESD. All remedial action work was completed safely and in an environmentally protective manner. A long-term monitoring and maintenance plan for the site is currently being developed in conjunction with USEPA.

1.0 INTRODUCTION

This Completion Report provides documentation of the remedial actions and associated monitoring conducted at the St. Lawrence River Remediation Project (SLRRP) site (the Site). The Site is adjacent to the Alcoa East Plant (former Reynolds Metal Company [RMC]) in Massena, New York. The work was performed to respond to the requirements of a 1993 Record of Decision (ROD) issued by the United States Environmental Protection Agency (USEPA) that required remediation of St. Lawrence River sediments north of the facility.

Remedial activities were initially conducted at the Site in 2001 when approximately 86,600 cubic yards (cy) (ex situ) of sediment were removed from the St. Lawrence River. An interim gravel cap was subsequently placed at the conclusion of the 2001 dredge season over 15 cells (out of 268 cells initially dredged) to isolate remaining sediment containing polychlorinated biphenyls (PCBs) above the target Remedial Action Level (RAL). Twelve of the 15 cells exceeded the target RAL for PCBs after the 2001 dredging; the remaining three cells were covered with the gravel cap because of they were within the footprint of the 12 PCBs cells exceeding the RAL. Completion of the interim cap for the residual PCB contamination was planned for 2002, but was postponed due to USEPA's concerns regarding residual polycyclic aromatic hydrocarbon (PAH) contamination detected in post-dredge sediment samples.

Following completion of dredging activities in 2001, Alcoa and USEPA entered into a dialogue on the appropriate scope of work for completion of the interim PCB cap and options to address residual PAH-impacted sediments at the St. Lawrence River site. These interactions prompted several auxiliary tasks, including a comparative evaluation of alternatives, an assessment of PAH toxicity and bioavailability in the remaining sediments, detailed PAH cap design analyses, and additional river sampling efforts, all of which were utilized to determine appropriate follow-up remedial actions to the 2001 work. Final remedial actions for the Site were formalized in an Explanation of Significant Difference (ESD) document, which was issued by USEPA in December 2008 (USEPA 2008).

This Completion Report addresses remedial work performed in 2001 and 2009 and has been divided into two separate volumes. Volume 1 of 2 (this document) summarizes the remedial construction activities conducted in 2001. Volume 2 of 2 describes the follow-up remedial action work completed in 2009 in accordance with the 2008 ESD to address residual sediments of concern remaining after the 2001 work.

1.1 PROJECT OBJECTIVE

The objective of the 2001 St. Lawrence River Remediation Project (SLRRP) was to implement the EPA-approved remedial design and work plans for remediation of river sediments with contamination above the ROD-specified cleanup goals. The project was designed, planned, and executed so as to accomplish this objective in a safe, cost-effective manner, with minimal impact on the environment, the surrounding community, or downstream receptors.

1.2 PURPOSE AND ORGANIZATION OF DOCUMENT

The purpose of this Volume 1 *Completion Report* is to document the type, scope, and effectiveness of remediation and monitoring activities conducted between March and December 2001. The document is organized as follows:

- **Section 1** presents an overview of the project objective, the regulatory basis for the work, safety and health, quality assurance, and interface with on-shore remediation activities.
- **Section 2** summarizes background information and the site history.
- **Section 3** describes the remediation processes, performance, and quality control measures.
- **Section 4** discusses environmental monitoring activities and summarizes monitoring results.
- **Section 5** addresses demobilization.
- **Section 6** discusses the results of the remediation, and includes an analysis of compliance with design and regulatory requirements.

The report also includes the following Appendices:

Appendix A – Key Contractors and Services Provided
Appendix B – Marine Construction Summary
Appendix C – Cell Status Report
Appendix D – Project Data Summary
Appendix E – Data Validation/Data Quality Assessment
Appendix F – Photographs
Appendix G – Construction Quality Assurance Report
Appendix H – Verification Sampling Logs
Appendix I – Water Treatment Plant Monitoring Reports

Appendix J and Appendix K listed in the original submittal of this document (*Draft Interim Completion Report for the St. Lawrence River Remediation Project*) in March 2002 are not referenced in this version based on the project history since that time. Appendix J was reserved for documentation of the planned construction completion activities which were expected to occur in 2002, and has been replaced by Volume 2 of this report; Appendix K was a risk calculation summary for residual PAH's that remained after the 2001 dredging. This information was not utilized by USEPA in the establishment of cleanup objectives in the 2008 Explanation of Significant Difference (ESD), which described the requirements for addressing residual PAH levels remaining after the completion of the 2001 construction activities. Attachment E to Appendix B is also not included in this report; it was previously submitted as an electronic copy under separate cover.

1.3 REGULATORY BASIS FOR WORK

In September 1989 the U.S. Environmental Protection Agency (EPA) issued a Unilateral Administrative Order (EPA Index No. II CERCLA-09230) under section 106(a) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, 42 U.S.C. §9606, that required RMC to investigate and clean up contamination in the St. Lawrence River study area associated with the RMC facility.

The 106 Order required RMC to undertake remedial action for the river, identifying specific requirements for collecting additional data, evaluating remedial alternatives, completing the design, and implementing the remedial action. It also specified the roles and responsibilities of EPA and RMC in the planning and execution of the work, identified milestones and scheduling requirements for submittals and notifications, and established the legal basis for enforcement of the Order.

Based on the results of the additional studies completed for the 106 Order, and a separate human health and ecological risk assessment completed by one of its contractors, EPA issued a Record of Decision in 1993 for the remediation of the St. Lawrence River adjacent to the RMC facility. The ROD was signed on September 27, 1993. Major components of the selected remedy included:

- Dredging and/or excavating approximately 51,500 yd^3 of sediments with PCB concentrations above 1 ppm, total polyaromatic hydrocarbon concentrations above 10 ppm, and total dibenzofuran concentrations above 1 ppb from contaminated areas in the St. Lawrence River and the associated river bank.
- Thermal desorption treatment of approximately 14,500 yd^3 of dredged/excavated material with PCB concentrations above 25 ppm. Untreated, dewatered sediments with PCB concentrations between 1 ppm and 25 ppm and treatment residuals (which are expected to have PCB concentrations below 10 ppm) were to be disposed of onsite in Black Mud Pond. The Black Mud Pond was to be capped in conformance with the requirements of the January 22, 1992, New York State Reynolds Record of Decision. Desorbed contaminants recovered during thermal desorption were to be sent to an offsite permitted commercial incinerator.

In 1995, the New York State Department of Environmental Conservation (NYSDEC) approved changes to the ROD covering remediation of PCB contamination on the RMC plant site. In April 1995, RMC requested that EPA make the following changes so that the ROD for remediation of the St. Lawrence River would be consistent with the NYSDEC ROD for plant remediation:

- Allow placement of material in the onsite landfill instead of Black Mud Pond [which had been capped as part of the plant (i.e., land-based) remediation work].
- Increase the maximum PCB concentration of material placed in the landfill from 25 ppm to less than 50 ppm to be consistent with NYSDEC limits.
- Remove the requirement for onsite thermal desorption and allow the disposal of sediments with PCB concentrations greater than or equal to 50 ppm at an offsite Toxic Substances Control Act (TSCA)-approved landfill.

In September 1998, EPA modified the Decision Document by issuing a Decision Document Amendment (i.e., a ROD Amendment) that changed several key components of the remedy dealing with the disposal of dredged sediment. The ROD Amendment specified the following changes to the 1993 ROD:

- Elimination of the onsite thermal desorption treatment component of the remedy
- Landfilling of all dredged and dewatered sediments with concentrations of PCB between 50 and 500 ppm at an approved, offsite facility
- Treatment of all dredged and dewatered sediments with PCB concentrations exceeding 500 ppm.
- Consolidation of all dredged and dewatered sediment with PCB concentrations less than 50 ppm in the on-site Industrial Landfill, which will be capped in compliance with NYSDEC's 1992 ROD and 1993 Consent Order for the land-based cleanup at the RMC facility.

All other components of the original remedy as selected in September 1993 ROD were not affected by the ROD amendment; these include dredging, cleanup goals, onsite treatment and discharge of dewatering liquids, and monitoring before, during and after dredging operations. In February 1999, the DEC issued an Explanation of Significant Differences to up-date the Administrative Record and the ROD to address the disposal of river sediments in the onsite landfill.

The 106 Order, 1993 ROD, and 1998 ROD Amendment served as the regulatory drivers for the remedial action work completed in 2001 for the St. Lawrence River Remediation Project. The subsequent regulatory history for the site following the completion of the 2001 construction activities is provided in Section 1.3 of Volume 2 of this document.

1.4 REGULATORY OVERSIGHT IN FIELD

A full-time staff consisting of representatives of EPA contractors, the U.S. Army Corps of Engineers, and NYSDEC oversaw the remedial action conducted in 2001. A representative of the Environment Division, St. Regis Mohawk Tribe, also conducted onsite oversight and worked closely with the project team on a number of air monitoring issues. In addition, the EPA Remedial Project Manager, made several visits to the site during the construction activities.

1.5 ENVIRONMENT, SAFETY, AND HEALTH

Worker and community safety was a prime consideration in the design, planning and execution of the St. Lawrence River Remediation Project. Worker safety addresses real-time health impacts with the potential for serious injury—or worse—for the individuals conducting the actual cleanup work. Worker safety was an integral component of all remedial construction-related activities, and in fact dictated many elements of how the work was actually accomplished in the field. The concerted efforts of the project team paid off with the nearly perfect safety statistics presented below.

The *Program Safety and Health Plan*, *Revision 4*, (Bechtel 2001) defined general (i.e., not area-specific) environmental, safety, and health requirements and delineated fundamental policies and guidelines for the work. An *Area-Specific Safety and Health Plan, Revision 4,* was developed for the river remediation tasks and addressed task-specific requirements and considerations associated with the on-shore activities. Both the Program and Area-specific plans were part of the *Remedial Action Work Plan* (Bechtel 2001). A *Marine Safety Plan* (Faust Corporation 2001) addressed all safety-related aspects of construction and operational activities that took place on the river. These included sheet pile installation and removal, dredging, sediment handling, barge movement, and tugboat operations.

A manual of standard operating procedures that provided implementation methodology supported the Program, Area-specific and Marine safety and health plans. Specific standard operating procedures addressed medical surveillance, training, air monitoring, personal protective equipment and clothing, respiratory protection, boating safety, rigging, and other activities. In addition, separate Task Safety Analyses were conducted for all work activities to ensure that work would be accomplished in a safe and effective manner. By the end of the project, over 150 such safety analyses had been performed.

A behavioral-based safety program implemented at the site involved a team of trained observers from the construction crafts chartered with developing and implementing a job-specific observation process to heighten awareness of activities that could cause injury. These teams met weekly, and by the end of 2001 a total of 32 meetings were held. The program was highly effective in giving the workers a sense of pride and ownership of the safety program and was a major factor in the overall safety performance of the project. Daily "Toolbox Safety Meetings," a crucial part of the behavioral-based safety program, were held daily with the construction personnel to discuss safety-related aspects of that day's work and solicit input from the workers on safety-related issues. A total of 170 Toolbox Safety Meetings were held in 2001.

The St. Lawrence River Remediation Project compiled an excellent record of environmental, safety, and health performance as shown in Table 1-1. Most noteworthy was that the project worked nearly half a million hours, much of this involving dangerous marine construction work (i.e., sheet pile installation and dredging) without a lost-time accident.

Table 1-1
St. Lawrence River Remediation Project Safety Statistics Summary

	Prior Years	2001	Cumulative
Total Jobhours	*180,058*	*258,373*	*438,431*
OSHA-recordable cases	0	0	0
Lost workday cases	0	0	0
Lost workdays	0	0	0
First Aid cases	0	6	6

The first aid cases that occurred in 2001 were all minor, ranging from slight sprains to scratches and bruises. First aid was administered in the field to the satisfaction of the employee, supervisors and the Site Safety and Health Officer.

As part of the remediation activities, RMC conducted air monitoring in the work areas and at the RMC facility boundary. Airborne chemistry sampling was conducted in the sediment handling areas for PCBs, polynuclear aromatic hydrocarbons (PAHs), silica, and total dust; results never exceeded the OSHA permissible exposure limits. Results from the personnel, area and boundary air sampling are discussed in Section 4.

Community safety was addressed primarily through the extensive environmental activities that RMC performed throughout the remedial construction work. This monitoring included the collection and analysis of more than a thousand water samples from the St. Lawrence River and downstream water supply systems. In addition, continuous air monitoring was conducted at boundary stations surrounding the dredging and on-site sediment handling areas and at locations on the St. Regis Mohawk Tribe (SRMT) Reserve.

RMC was also highly responsive to community concerns in the area of environmental monitoring. For example, when residents of the SRMT community notified RMC that an illness on the SRMT Reserve was due to dredging operations, the dredging was suspended for 3 days. RMC conducted an extensive monitoring and testing program in coordination with the SRMT Environment Division to help determine the source of the illness. Although no source could be pinpointed, it was determined that the dredging operations were not impacting the SRMT Reserve.

RMC also monitored the water intakes of the SRMT, GM, and RMC potable water plant. Over 260 water intake samples were collected and no valid detection of contamination was found in any of these water supplies. A few detections were reported, but were later found to be internal laboratory issues. These results were consistent with the more than 1,000 water samples obtained from the St. Lawrence River in the immediate vicinity of the dredging operations, which also showed that the project had no impact on water quality in the river.

1.6 CONSTRUCTION QUALITY ASSURANCE

Construction quality assurance was performed in accordance with the *Construction Quality Assurance Plan*, which was part of the *Remedial Action Work Plan* (Bechtel 2001). The construction quality assurance manager and the construction quality assurance program were independent of all other project management functions, and the construction quality assurance manager reported directly to the Reynolds remediation project director, with direct lines of communication to the regulatory oversight personnel. Appendix G includes a construction quality control report written by the project's construction quality assurance manager.

1.7 INTERFACE WITH SITE REMEDIATION

Remedial activities at the RMC St. Lawrence Reduction Plant have involved two separate projects: the land-based (plant site) remediation and the river remediation. This report deals with the River Remediation Project only.

The physical interface between the site and the St. Lawrence River work occurs at the river's edge along the shoreline north of Haverstock Road. The interface was defined as being 2 ft (vertical) above the mean water surface elevation of the river. The logistical interface is at the onsite Landfill. Capping of the landfill occurred in 2002 in accordance with the NYSDEC-approved *Closure Cap Design for the Landfill/Former Potliner Storage Area, Rev. 1* (Bechtel November 1996).

2.0 BACKGROUND AND SITE HISTORY

This section presents background information that describes the physical setting of the remediation site and summarizes the extensive level of effort that has been expended in the characterization, design and planning of the remediation work that was completed in 2001.

2.1 SITE DESCRIPTION

The 1989 CERCLA 106 Order defined the "Reynolds Study Area" to include those portions of the St. Lawrence, Grasse, and Raquette Rivers, their tributaries, and associated wetlands, which were adjacent to the RMC facility. Since that time, various studies have better defined the areas requiring remedial action. The Grasse River is being addressed separately by EPA as part of a separate remediation project. The wetlands on the RMC property were investigated and remediated as part of the NYSDEC's land-based cleanup. The Raquette River section in the Reynolds Study Area did not show contamination requiring remediation. The St. Lawrence River portion of the study area was originally defined as that portion of the river between the mouth of the Grasse River in the west to the International Bridge in the east, and from the southern shoreline of the river to the southern edge of the Cornwall Island navigational channel (part of the St. Lawrence Seaway) within the river.

Following additional characterization studies and evaluation, the focus of remediation activities was narrowed to an approximate 3,500-ft-long portion of the river immediately north of the RMC facility, extending, on average, about 450 ft from the southern shoreline into the river. This area of approximately 30 acres corresponds to the "site" or "remediation area" as used in this report and is shown in Figure 2-1. A detailed description of the remediation area is presented in Section 2.1.3.

2.1.1 Hydrodynamic Conditions in the St. Lawrence River

The channel for the St. Lawrence River in this area is divided by Cornwall Island. Just upstream of the site are the Moses-Saunders Power Dam of the New York Power Authority and Long Sault spillway dam. Flow through the dam averages 240,000 cubic feet per second (cfs). Approximately two thirds of this flow is directed through Pollys Gut into the Cornwall Island Navigation Channel adjacent to RMC. The flow through Pollys Gut (about 160,000 cfs) is diverted eastward by 2 riprap dikes that produce a current with a core velocity in excess of 8 ft per second (fps). The RMC plant is also downstream of the Snell Lock, which contributes less than 400 cfs when discharging, and the Grasse River, which has an average flow on the order of 1,100 cfs.

Circulation patterns at the site have been extensively studied, both by the Seaway Authority, for navigational purposes, and by RMC, primarily to understand the relationship between river currents and the distribution of contaminated sediment. Additional studies were completed during the remedial action activities in 2001 to support environmental monitoring activities. An understanding of river current and circulation patterns is an important factor in the design and implementation of both remediation and monitoring activities. For this reason, the results of studies available in advance of the 2001 construction activities are summarized below. Additional hydrodynamic studies conducted following the 2001 work are described in Volume 2 of this report.

The initial river circulation studies conducted in the St. Lawrence River by the Seaway Authority identified a strong eastward (downstream) flow in the center of the channel with a southward (onshore) movement and a series of vortices off the RMC plant. As part of their initial sediment characterization work, Woodward-Clyde Consultants (WWC) did an extensive current study in 1988.

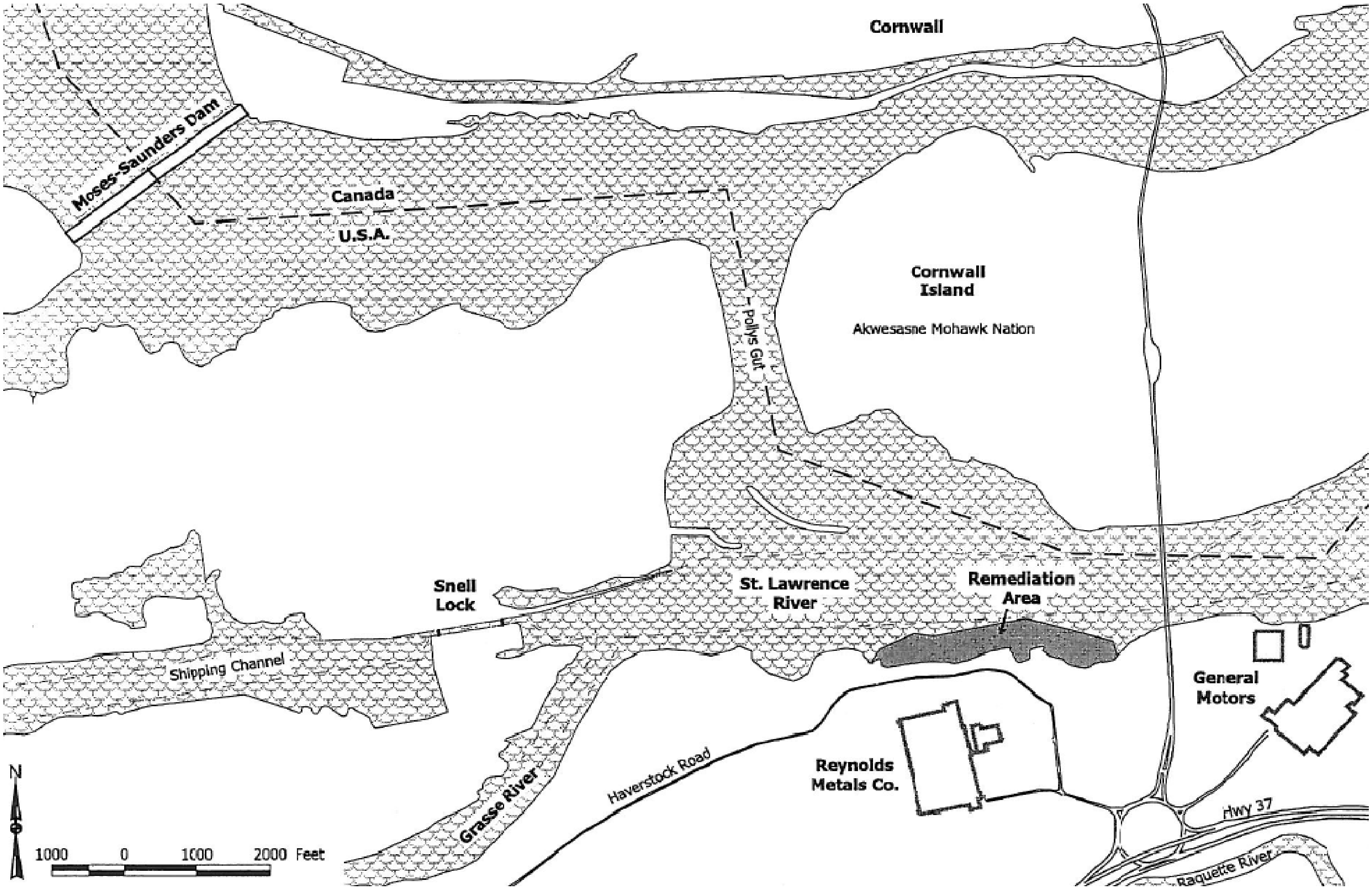

Figure 2-1
Remediation Site and Surrounding Areas

2.1.1 St. Lawrence Reduction Plant Outfalls

As stated in the 1998 ROD Amendment, contamination in the near-shore sediment in the St. Lawrence River was attributed to "uncontrolled surface water run-off and wastewater discharges from the outfalls at the Reynolds facility." A brief overview of the RMC outfalls into the St. Lawrence River is presented below.

RMC industrial discharges have evolved in response to regulatory changes as well as modifications and upgrades in the plant's process lines, water treatment plants, and storm water management systems. At the time of the initial (1988-1989) sediment characterization studies, there were seven discharge points into the St. Lawrence River; these outfalls, shown in Figure 2-3, include the following:

- *Former Outfall 001*: the westernmost of the four points, it discharged bleed water from the industrial wastewater treatment system and also surface water runoff from the majority of plant, including the north plant yard. Water left this outfall approximately 30 ft above river level and cascaded down a paved slope to enter the river along an open stretch of shoreline (the structure is still present on the riverbank).
- *Former Outfall 002*: the easternmost of the outfalls, it discharged cooling water and storm water runoff from some sections of the plant. It carried the highest volume of water of the four outfalls, averaging approximately 2.5 million gallons per day. The discharge cascaded down an open ditch to enter the river at the head of a shallow cove.
- Form*er Outfall 003*: discharged effluent from the plant sanitary treatment plant through a submerged pipe in the shallow cove.
- *Former Outfall 004*: carried intermittent discharges from diked areas in the northern part of the plant; located between 001 and the cove associated with 002 and 003 (Outfall 004 was subsequently designated 006 by NYSDEC).
- *Former Outfall 005*: carried storm water from the employee parking lot and eastern, undeveloped portions of the RMC property, including both mowed and weeded areas.
- *Former Outfall 007*: carried storm water from a small area south of Haverstock Road.
- *Former Outfall 008*: carried storm water from the western part of the plant.

By the time of the sediment remediation activities, the outfall configuration had changed significantly. There were now four primary outfalls, all of which are closely regulated and monitored under the NYSDEC SPDES program, but the locations and configurations of some of the discharges had been modified. The information provided below represents the status of the plant outfalls at the time of the 2001 sediment remediation activities:

- *Outfall 008*: located near the western edge of the river study area, discharges storm water from the western part of plant
- *Outfall 002/003*: discharges through the submerged pipe in the shallow cove that was formerly used for 003 alone; it is a combined outfall of 2 independently monitored discharge streams: 002 discharges process cooling water and storm water from the eastern third of plant while 003 discharges effluent from the RMC sewage treatment plant.

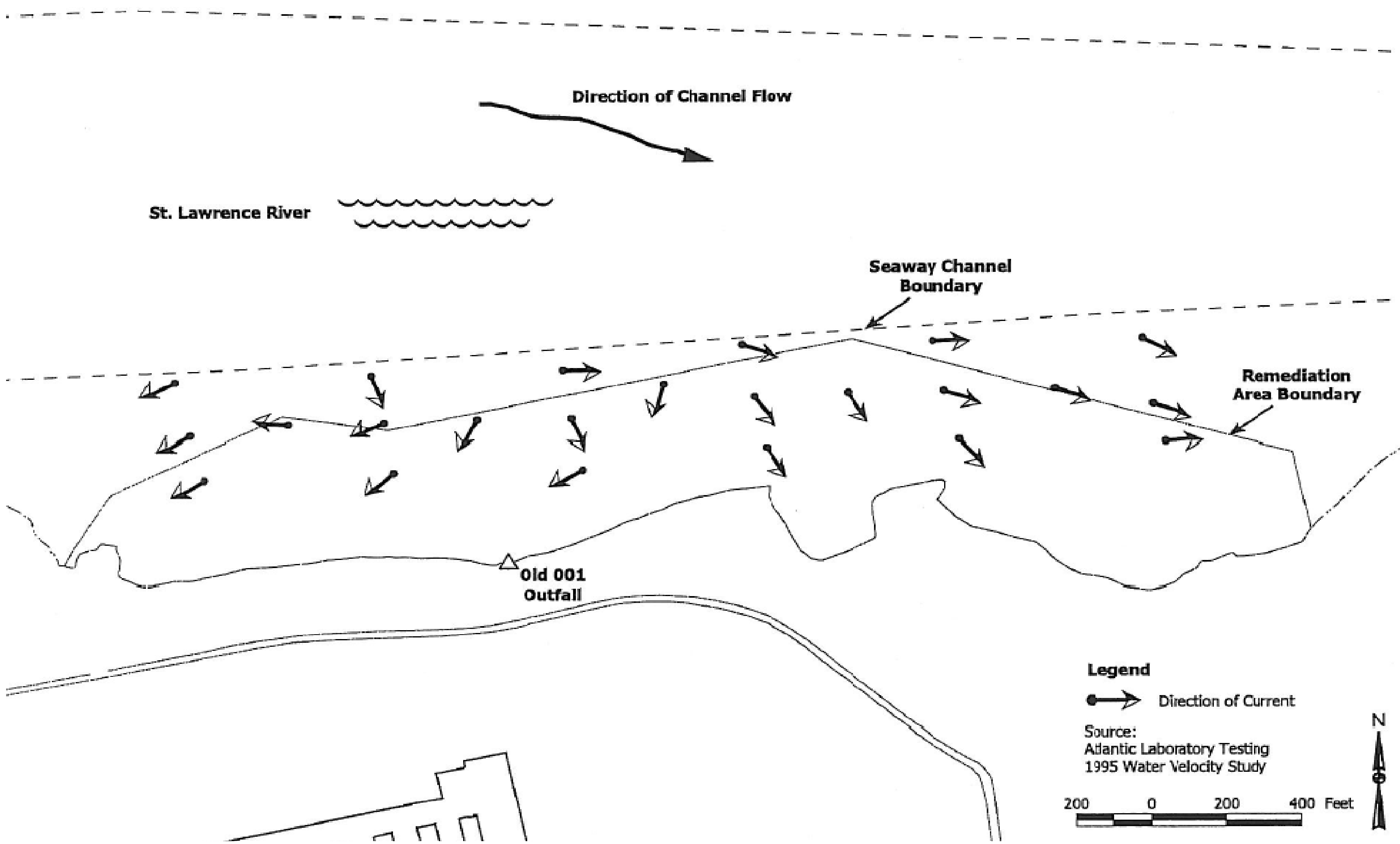

Figure 2-2
Direction of River Currents

2.1.2 St. Lawrence Reduction Plant Outfalls

As stated in the 1998 ROD Amendment, contamination in the near-shore sediment in the St. Lawrence River was attributed to "uncontrolled surface water run-off and wastewater discharges from the outfalls at the Reynolds facility." A brief overview of the RMC outfalls into the St. Lawrence River is presented below.

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- *Former Outfall 001*: the westernmost of the four points, it discharged bleed water from the industrial wastewater treatment system and also surface water runoff from the majority of plant, including the north plant yard. Water left this outfall approximately 30 ft above river level and cascaded down a paved slope to enter the river along an open stretch of shoreline (the structure is still present on the riverbank).
- *Former Outfall 002*: the easternmost of the outfalls, it discharged cooling water and storm water runoff from some sections of the plant. It carried the highest volume of water of the four outfalls, averaging approximately 2.5 million gallons per day. The discharge cascaded down an open ditch to enter the river at the head of a shallow cove.
- Form*er Outfall 003*: discharged effluent from the plant sanitary treatment plant through a submerged pipe in the shallow cove.
- *Former Outfall 004*: carried intermittent discharges from diked areas in the northern part of the plant; located between 001 and the cove associated with 002 and 003 (Outfall 004 was subsequently designated 006 by NYSDEC).
- *Former Outfall 005*: carried storm water from the employee parking lot and eastern, undeveloped portions of the RMC property, including both mowed and weeded areas.
- *Former Outfall 007*: carried storm water from a small area south of Haverstock Road.
- *Former Outfall 008*: carried storm water from the western part of the plant.

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- *Outfall 008*: located near the western edge of the river study area, discharges storm water from the western part of plant
- *Outfall 002/003*: discharges through the submerged pipe in the shallow cove that was formerly used for 003 alone; it is a combined outfall of 2 independently monitored discharge streams: 002 discharges process cooling water and storm water from the eastern third of plant while 003 discharges effluent from the RMC sewage treatment plant.

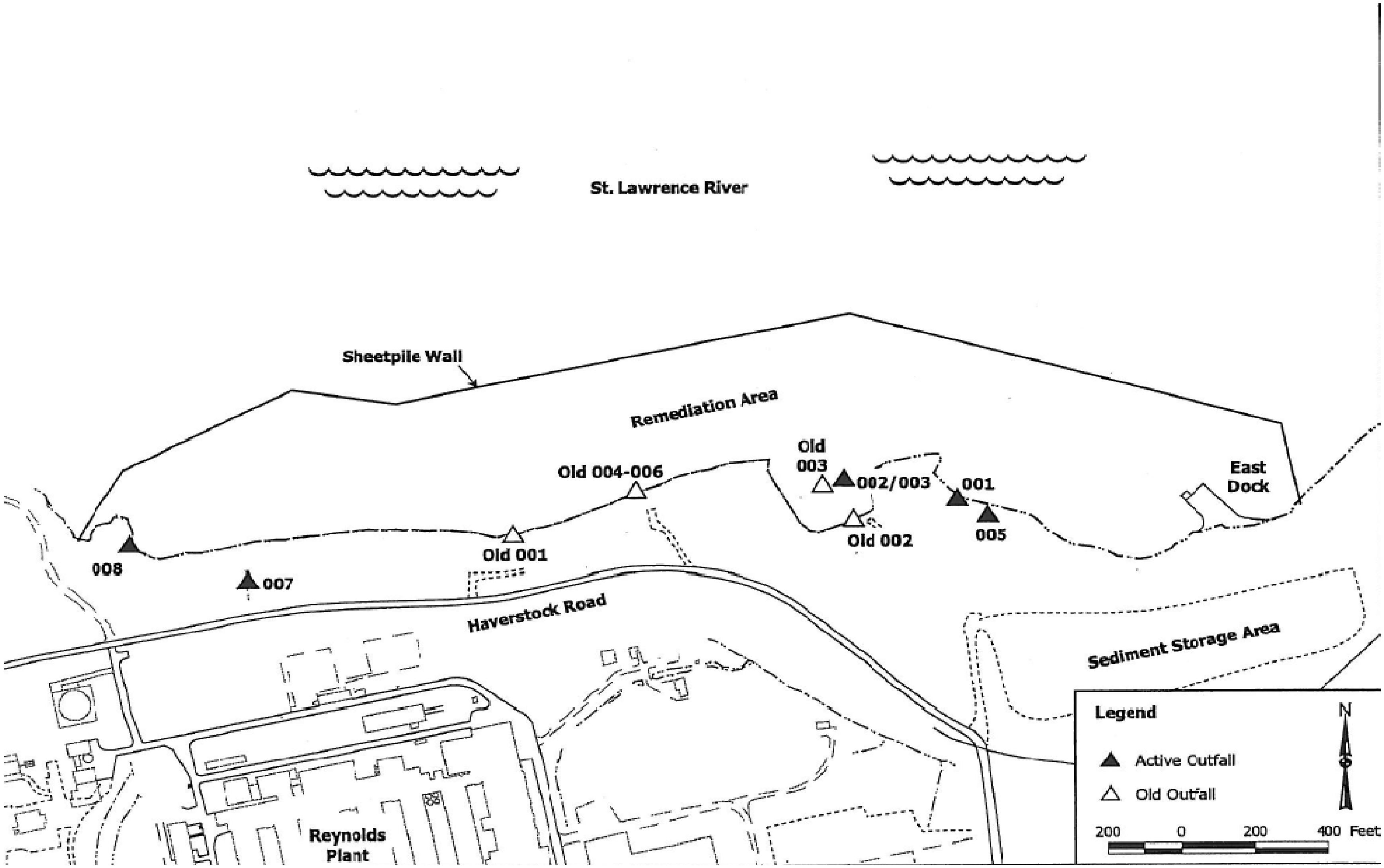


Figure 2-3
Reynolds Plant Outfalls

- *Outfall 001:* discharges effluent from the detention basin and sand filter that receive treated water from the Wastewater Treatment System and storm water runoff from about two-thirds of the plant. The outfall is located just east of the eastern headland associated with the shallow cove where 002/003 discharges.
- *Outfall 005:* discharges storm water from the employee parking lot and eastern, undeveloped portions of the RMC property, including both mowed and wooded areas. The outfall is located about 50 ft east of the 001 outfall.

The former 004 (later re-designated 006) outfall was eliminated during the land-based remediation activities; its water was directed into the 001 discharge stream. The locations of current St. Lawrence River outfalls are shown in Figure 2-3.

2.1.3 Remediation Area

The area to be remediated was defined on the basis of the early studies by WWC as well as later sampling efforts completed during the remedial design phase of the project. The initial basis for the remediation area was based on the mapped distribution of sediment contamination as reported by WWC in their *Additional River Sampling Program Report* (WWC 1991). WWC presented PCB isoconcentration contours for the depth intervals of 0-8 in., 8-16 in., and >16 in., as well as PAH and total furans (PCDFs) for all depths. The mapping of contamination, based on the collection and analysis of 208 sediment samples from 96 locations, was summarized in a figure depicting the "areal extent of contamination" in St. Lawrence River sediment. This WWC figure is reproduced in this report as Figure 2-4.

The configuration of the remediation area was revised following the 1996 *Final Report, Sampling and Analysis for the River Remediation Project* (Bechtel Dec 1996). A total of 206 additional sediment samples were collected for this 1996 study, which resulted in a slight shifting of boundaries for both contaminated and uncontaminated areas within the broader remediation area. These results, along with those from the earlier WWC studies, formed the basis for the final configuration of the remediation area, upon which the 2001 remedial action was based, and which was approved by EPA as part of the *Final Dredging Program Design Report* submitted in May 2000.

As stated above, the remediation area or site is approximately 30 acres in size, of which approximately 22 acres was eventually remediated (the remaining portions were not contaminated). The area had an average water depth of about 10 ft, with a maximum of about 27 ft. Bottom topography (bathymetry) was highly irregular due to the creation of a shallow shelf by the dumping of dredge spoil during construction of the Cornwall Island Navigation Channel. The dredge spoil was placed with hopper dredges (bottom-opening) between 1957 and 1959. Discharges from the plant began after placement of the dredge spoil and no spoil was placed after discharges began.

Figure 2-5 presents pre-dredging bathymetry over the dredge area. It was anticipated during the design and planning stages of the project that the irregular topography resulting from the historical dumping of dredge spoils would create access problems for the barges. The project team assumed that some preliminary "navigational" dredging would be required to allow for barge access. Observations and additional navigational surveying, completed during installation of the sheet pile wall, identified a greater number of underwater obstructions than originally anticipated, leading to a larger navigational dredging program than anticipated. Other factors contributing to an increase in navigational dredging were low water levels in the St. Lawrence River and the need to accommodate the deeper drafts of the marine equipment mobilized to the site that was larger than anticipated. This dredging is discussed in Section 3.

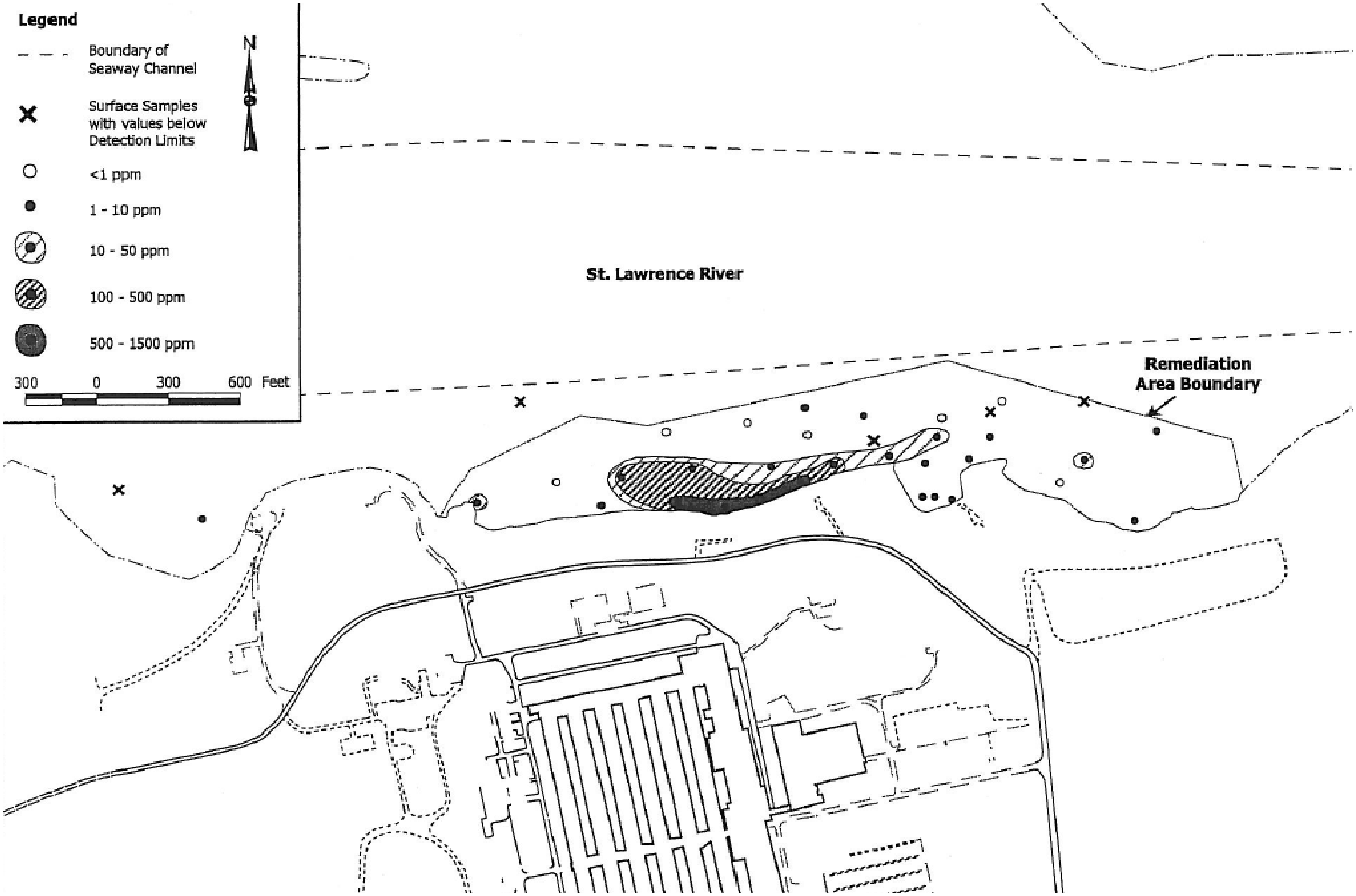


Figure 2-4
Areal Extent of Contamination

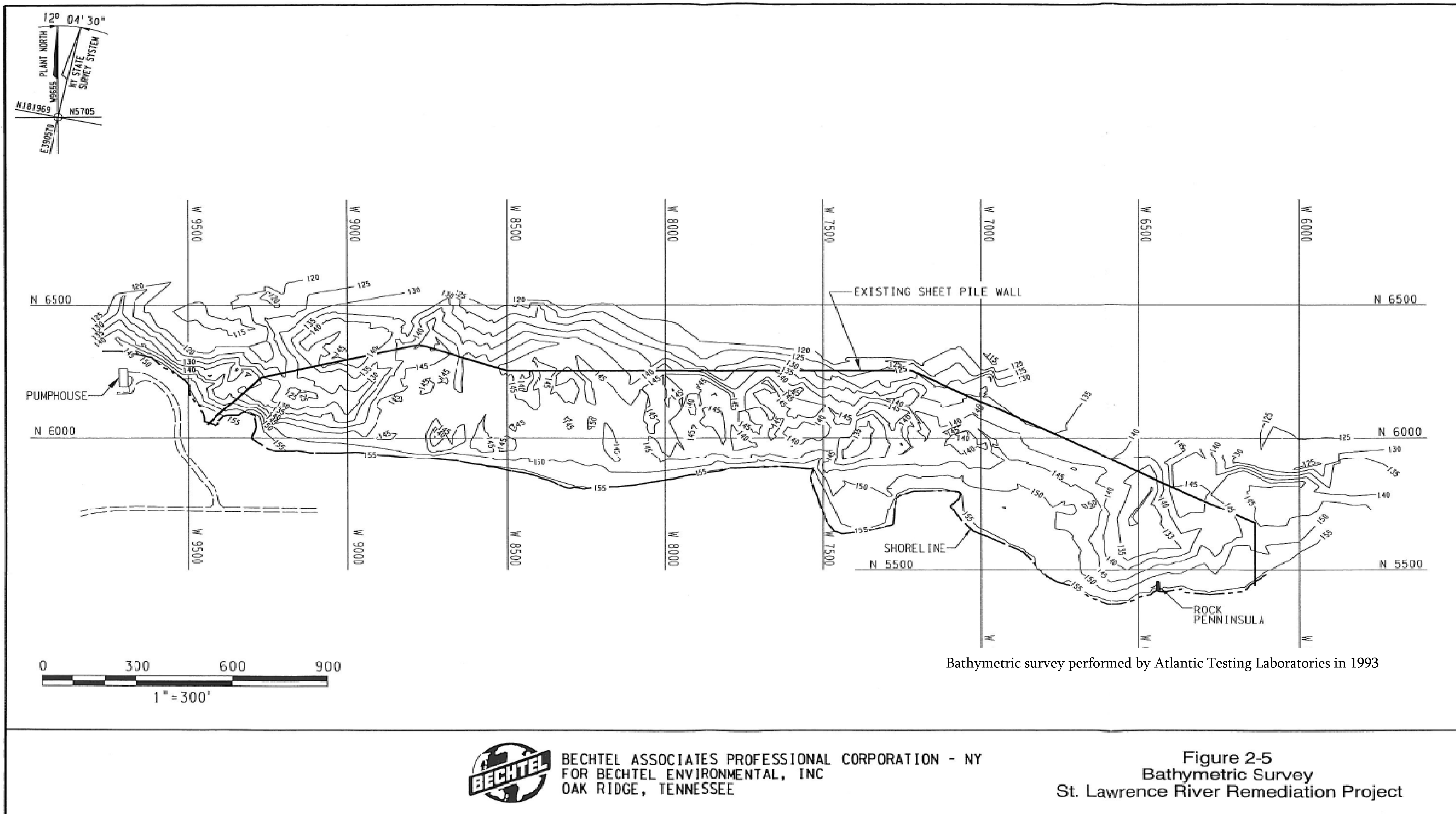


Figure 2-5
Pre-dredging Bathymetry

Prior to the remediation work, the offshore areas between 2.5 and 12.5 ft in depth were associated with thick stands of aquatic (submerged) vegetation. A vegetative survey conducted in 1992 identified the predominant plant species as milfoil (Meriophyllum spp.), coon tail (Ceratophyllium demersum), wild celery (Vallisneria Americana), waterweed (Elodia Canadensis) and various algae. Prior to the start of dredging, an aquatic herbicide (diquat bromide) was applied to suppress the vegetation; this activity is described in Section 3.

The 30-acre remediation area that was eventually enclosed with a steel sheet pile wall was subdivided into four subareas: A, B, C, and D, as shown in Figure 2-6.

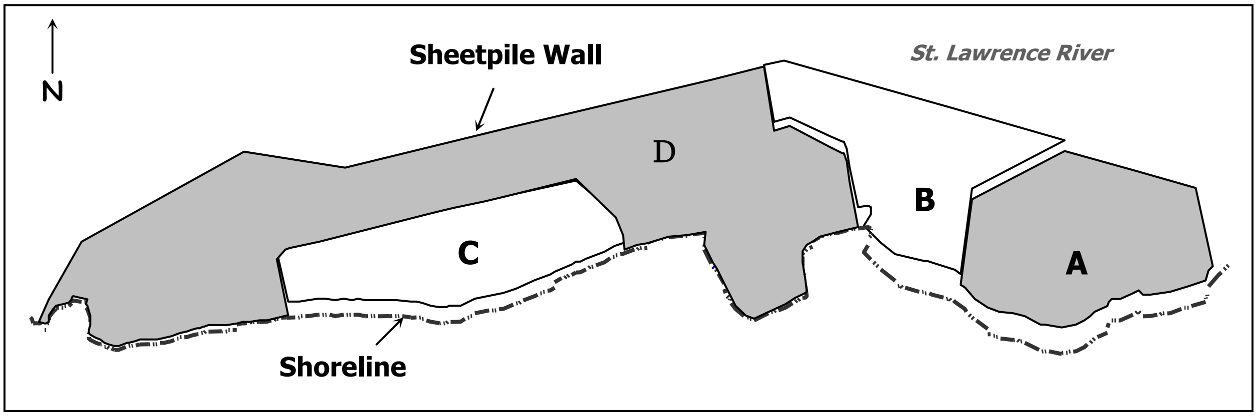


Figure 2-6
Remediation Area and Subareas

- **Area A** lies in the eastern portion of the remediation area, consisting of an area of 5.85 acres, of which 3.38 acres required dredging in 2001. The East Dock was constructed along the southern margin of Area A for the unloading of contaminated sediment.
- **Area B** consists of approximately 5.03 acres, the majority of which was not contaminated and protected during the remediation by silt curtains. Two dredge cells in Area B, comprising an area of 0.15 acres, were remediated.
- **Area C** was 5.05 acres in size, of which 4.90 acres required dredging during 2001.
- **Area D** consists of the western and northern portions of the remediation area, encompassing an area of 15.06 acres, of which 13.40 acres required dredging in 2001.

The contaminated portions of each area were further divided into individual dredge cells, based on the triangular sampling grids used for the *Area A Sampling and Analysis Plan* (July 1996). The configuration of the sampling grids was developed on the basis of earlier statistical studies and input from EPA. A dredge cell is a dredging area with one point (location) of the sampling grid in its center. Verification sampling locations in Areas A, B, and D reflect a triangular grid spacing of 70 ft; locations in Area C are based on a triangular grid spacing of 50 ft. A total of 268 dredge cells were defined within the remediation area (Figure 2-7).

Areas A, B, C, and D were also combined into one of 3 Evaluation Areas used for statistical evaluation of post-dredging conditions. Further discussion of Evaluation Areas, which are shown on Figure 2-7, is presented in Section 3.

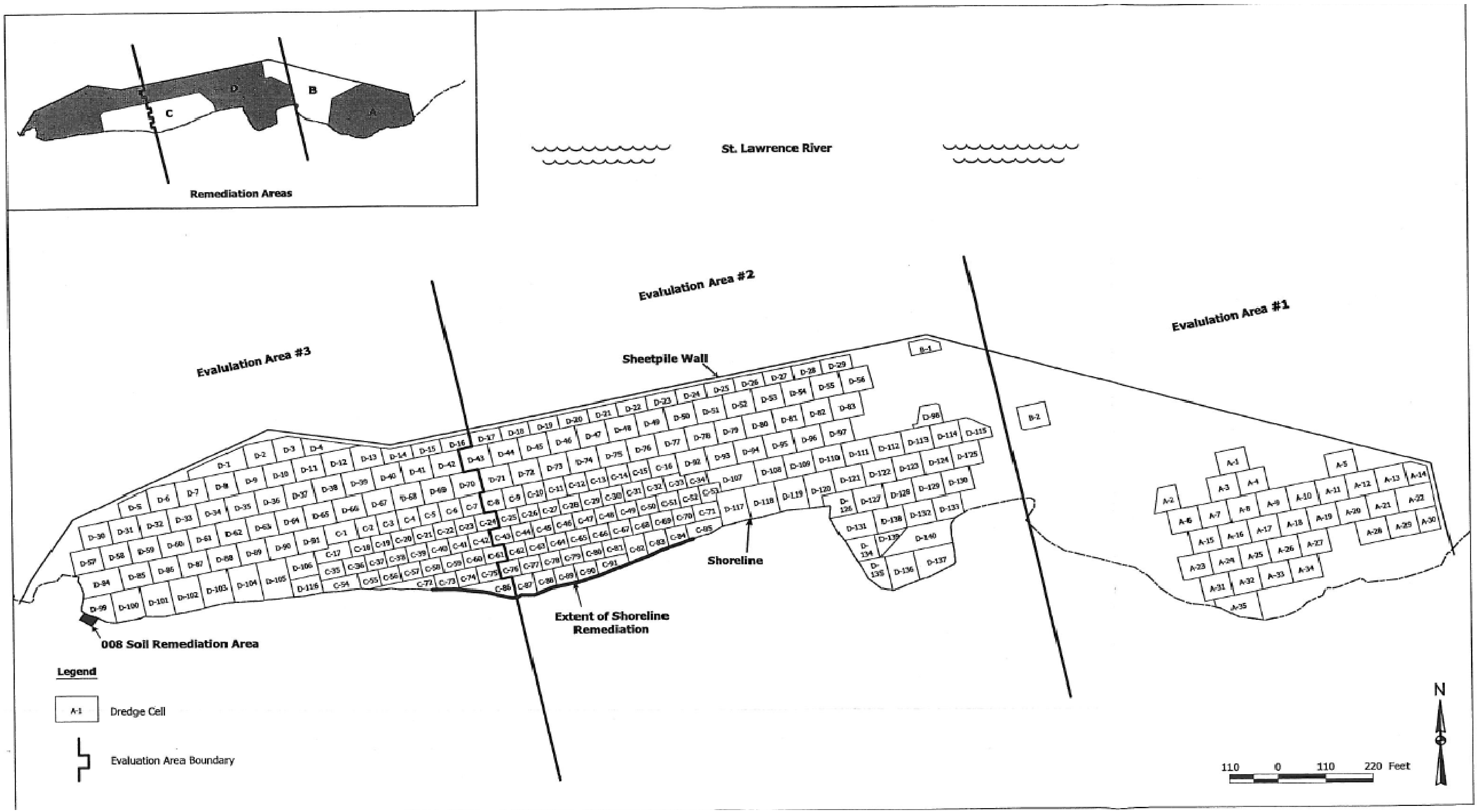


Figure 2-7
Dredge Cells, Evaluation Areas, and Shoreline Remediation Area

Also included in the remediation area was an approximate 625-ft long section of riverbank along the shoreline of Area C, between east coordinate W7865 and west coordinate W8485. The area consists of an approximate 3-ft wide by 1-ft deep strip bounded by the water's edge (nominally 156 ft MSL) to the north and a line corresponding with an elevation approximately 2 ft above the water's edge (i.e., 158 ft MSL) to the south, which marked the northern extent of land-based remediation work completed earlier by RMC under a separate project ("Area North of Haverstock Road") in 1994. The location of this shoreline segment is shown in Figure 2-7.

As part of the remediation work, an area of contaminated shoreline soils associated with the 008 outfall was also excavated. These soils, in an area of approximately 2,500 ft^2, were determined to have PCB contamination requiring remediation during the land-based cleanup work. Due to access problems, however, it was decided to wait until the rive remediation work was completed to remove these soils. The location of the 008 excavation area is also shown in Figure 2-7.

2.2 SITE HISTORY

The St. Lawrence River Remediation Project has evolved considerably over time as additional studies were completed generating new information, regulatory decisions were finalized and then modified, and lessons learned from nearby remediation projects were incorporated into the final remedy for the site. The following section highlights the previous investigations completed for the project, which is then followed by a narrative that outlines the evolution of the remedial action from the initial concepts developed after the 1993 ROD to the final configuration of the project as implemented in 2001.

2.2.1 Previous Investigations, Studies, Engineering Evaluations, and Related Activities

RMC completed an extensive array of investigations, testing programs, and engineering studies in support of river remediation project. The following is a brief summary of these previous investigations conducted and reports generated for the project since 1988:

- *Sediment Sampling Work Plan and Results of Hydrodynamic Study, St. Lawrence River Sediment Sampling Program* (WCC August 1988). A plan for the initial investigation into sediment contamination in the St. Lawrence River. Its objectives were to characterize the extent of PCB contamination, assess the importance of the RMC outfalls as potential sources of contamination, assess the potential for other (non-RMC) sources of PCB contamination, and characterize contaminant transport processes in the river near the plant. The report included results from an initial hydrodynamic study of river currents in the vicinity of the plant.

- *Final Report of the St. Lawrence River Sediment Sampling (RSS) Program* (WCC January 1989). The report delineated sediment PCB contamination along the St. Lawrence River shoreline near the RMC plant and included results from additional hydrodynamic studies of river currents in the vicinity of the RMC plant.

- *Additional River Sampling (ARS) Program* (WCC August 1991). Completed in accordance with the 106 Order, this study provided further identification and delineation of sediment contamination in the St. Lawrence River near the RMC plant.

- *Treatability Study Report for St. Lawrence River Sediments* (WCC January 1992). Bench-scale testing conducted to evaluate treatment technologies for contaminated sediments; the technologies evaluated included a solvent extraction process and thermal desorption.

- *Final Risk Assessment* (TRC September 1993). Baseline human health and ecological risk assessment conducted by an EPA contractor (TRC Environmental Corporation).

- *Analysis of Alternatives for the Saint Lawrence River System* (WCC January 1993). A feasibility study completed in accordance with the 106 Order. The study identified, screened and assembled remediation technologies into remedial alternatives, which in turn were subjected to a detailed analysis to identify the preferred alternative for remediation of contaminated sediment in the St. Lawrence River.

- *Remedial Design Plan for Remediation of the St. Lawrence River in Accordance with the Record of Decision, Rev. 0* (Bechtel November 1993). Defined (1) the scope of activities to be performed in association with the remediation activities defined in the ROD, and (2) the procedures and protocols to be used in performing the scope of activities.

- *Bathymetric Characterization of the St. Lawrence River* (ATL June 1993). Delineation of bottom topography in the area to be dredged; completed in support of remedial design activities.

- *Initial Dredging Program Preliminary Design Report, Rev. 0* (Bechtel June 1994). Presented the conceptual design for the initial dredging program, including technical specifications and design drawings, procedures, a contingency plan, and contractor scopes of work for procurement.

- *Initial Dredging Program Work Plan for the River Remediation Project* (Bechtel July 1994) Describes the initial dredging program which included the dredging of three test areas in the St. Lawrence River north of the reduction plant.

- *Geotechnical Sampling and Analysis Program* (ATL June 1994). Presented the results of geotechnical and PCB testing conducted in the areas to be dredged under the initial dredging program. The focus of the study was on the characteristics of the sediment to be dredged.

- *Pre-Remediation Baseline Ecological Sampling Plan* (WCC September 1994). Defined the ecological data to be collected to establish baseline conditions as needed to evaluate the effectiveness of the remedial action after its implementation.

- *Treatability Testing Report on the River Sediments* (OHM December 1994) and *Additional Treatability Testing Report on River Sediments* (OHM February 1995). Bench-scale tests were conducted on sediment samples collected in 1994 and 1995 to resolve issues regarding dewatering, filtration, water quality of elutriate, and compaction of dewatered sediments.

- *Final Baseline Ecological Monitoring Report* (WCC April 1995). Documented baseline ecological conditions at a reference location and within the remediation area as well as the viability of selected monitoring techniques for evaluating the effectiveness of the sediment remediation.

- *Work Plan for Velocity and Geotechnical Studies for the River Remediation Project* (Bechtel August 1995). A plan that defined the scope, equipment and materials, procedures, and data evaluation processes for information needed to support design of the sheet pile wall.

- *H-Pile Installation Test* (Sevenson Environmental Services September 1995). Installation test included the installation and removal of an H-beam into the till at two locations along the sheet pile route.

- *Videotape of Sheet Pile Route* (M&E September 1995). Transects along the sheet pile route were videotaped to identify bottom conditions and possible obstructions to pile installation.

- *Velocity and Wave Height Summary* (ATL October 1995). ATL collected river velocity and ship wake data in support of the design of the sheet pile wall.

- *Geotechnical Laboratory Soil Testing* (ATL October 1995). Additional geotechnical work conducted to support design of the sheet pile wall, concentrating on the characteristics of deeper sediments/soils along the route of the proposed wall.

- *Final Dredging Program Work Plan for the River Remediation Project Rev. 1* (Bechtel November 1995). Contains the conceptual design and describes activities necessary to complete a full-scale dredging program. This work plan was superseded by subsequent revisions (see below).

- *Final Dredging Design Report - Braced Sheet Pile Design* (M&E November 1995) Incorporated results from velocity, geotechnical and H-Pile installation studies to provide the detailed design of the sheet pile containment structure.

- *Area A Sampling and Analysis Plan, Rev. 2* (Bechtel July 1996). Defined the scope and procedures for a pre-dredging sampling investigation in Area A, which EPA and RMC agreed to use to determine the technical limits of dredging.

- *Final Dredging Program, Area A Operations Plan, Rev. 1* (M&E July 1996). Presented a plan for dredging of Area A to collect information needed to evaluate sediment removal, contaminant reduction, and other factors related to the overall dredging program. Dredging was to be conducted in selected blocks in Area A representative of the varying bottom conditions present across the remediation area.

- *Final Report – Sampling and Analysis for the River Remediation Project* (Bechtel December 1996). Provides PCB results from sediment samples collected from Areas A, B, and D in 1996. The sampling effort had 2 objectives: (1) provide data from Area A to be used in determining the technical limits of dredging in meeting the cleanup goals; and (2) provide more detailed delineation of areas to be remediated in Areas D and B.

- *Final Dredging Program Work Plan for the River Remediation Project, Rev.3* (Bechtel May 2000). Revised work plan reflected the 1998 changes to the ROD (i.e., the ROD Amendment), additional changes requested by EPA, and updated findings from the 1996 sampling report as well as other design studies and investigations.

- *Final Dredging Program Design Report for the River Remediation Project, Rev. 3 (M&E May 2000).* Identified the basis of design for the approach, equipment selected and design calculations needed to implement the Final Dredging Program; the remediation work completed in 2001 was based on this design report.

- *Final Dredging Program Remedial Action Work Plan, Rev. 1 (Bechtel June 2001).* Presented the QA Plan, Construction Quality Assurance Plan, Contingency Plan, Safety and Health Plans, and Environmental Monitoring Plan.

2.2.2 Narrative of the Post-Rod Remedial Design and Planning Process

Following issuance of the ROD in September 1993, RMC submitted the *Remedial Design Plan for Remediation of the St, Lawrence River in Accordance with the Record of Decision* to EPA in November 1993. The purpose of this plan was to identify (1) the scope of remediation activities to be performed in accordance with the requirements defined in the ROD and (2) the procedures and protocols to be used in completing the defined scope of activities. At this point in time, the River Remediation Project was divided into three major tasks: the initial dredging program, the final dredging program, and the sediment treatment program.

The initial dredging program was planned to include the dredging of three test areas in the St. Lawrence River, while the final dredging program was to address the balance of the remediation area. In the summer of 1994, RMC submitted the *Preliminary Design Report for the River Remediation Project* (June) and *Initial Dredging Program Work Plan for the River Remediation Project* (July) to define the design basis, scope and methods to be used for dredging of the 3 test areas.

In June 1994, RMC solicited bids from three dredging and remediation companies for the initial dredging program. Only one firm responded by the bid closing date. After reviewing the bid, RMC determined that the proposed schedule was unsatisfactory, as it would not allow work to be completed by the end of the 1994 construction season. Consequently, RMC notified EPA that the initial dredging program would be postponed until 1995.

During the fall of 1994, General Motors (GM) attempted to dredge PCB-contaminated sediments from the St. Lawrence River near its GM Powertrain plant, located immediately downstream from the RMC plant. GM's dredging contractor encountered problems using silt curtains for sediment control, and their dredging work was postponed until 1995.

The plans and specifications for RMC's initial dredging program were revised to take into account the lessons learned at the GM site, and in December 1994, RMC solicited bids from nine dredging and remediation contractors using the revised plans and specifications. During this time, RMC conducted treatability studies to determine design parameters for sediment dewatering and water treatment (OHM 1994, 1995).

In January 1995, RMC provided the bidders with the results of the dewatering and water treatment study and extended the bid due date until the end of February. By the bid closing date, RMC had received no-bid responses from all of the potential bidders. A significant number of bidders cited uncertainties concerning current velocities in the area to be dredged and the effectiveness of silt curtains as a reason for not bidding. EPA was notified of the lack of response to the request for bids in March 1995.

In consultation with EPA, RMC revised the initial dredging program in April 1995 to require the dredging of sediments with PCB concentrations greater than 500 ppm in 1995. While GM was to use sheet piling during its 1995 dredging work, EPA agreed that RMC was to evaluate methods other than sheet piling and silt curtains for sediment control. During the spring and early summer of 1995, GM's new dredging contractor began the installation of sheet piling at the GM site.

Also in April 1995, RMC requested that EPA modify the 1993 ROD to reflect changes to the NYSDEC decision document governing land-based remediation for the St. Lawrence Reduction Plant. The goal was to establish consistency between the cleanup of the river with that being done for the land-based remediation. The requested changes, discussed in Section 1.3 above, addressed components of the remedy that primarily dealt with the disposal of the dredged sediment.

During the same period, RMC completed contractor selection and began contract negotiations with Metcalf and Eddy, Inc., for the initial dredging program at the RMC site. In parallel with contract negotiations, work began on the identification and evaluation of silt-control alternatives. By the end of June, it was apparent that the contractor at the GM site would be able to successfully complete the installation of sheet piling, and at the same time RMC determined that none of the other silt-control alternatives under evaluation would be as effective as sheet piling.

In July 1995, RMC notified EPA that sheet piling would be used for silt control and proposed a new plan for removing contaminated sediments. Under the new plan, the initial dredging program would be eliminated, and the final dredging program would begin in 1996. In August 1995, RMC submitted a work plan for velocity and geotechnical studies to EPA; these studies were conducted during the fall of 1995.

In November 1995, RMC submitted the *Final Dredging Program Work Plan (Revision 1)* to EPA. The work plan contained the conceptual design and described the activities necessary to complete the remediation work. RMC also submitted the *Braced Sheet Pile Design Report* at this time, which contained a detailed design of the sheet pile wall.

In January 1996, RMC requested that EPA revise its 1993 Decision Document to allow RMC to establish a >50 ppm PCB footprint, dredge within the footprint to an average of <25 ppm PCBs, and cap all areas where PCB concentrations were 0.1 ppm. This proposal was rejected by EPA in February 1996.

In February 1996, RMC submitted the *Final Dredging Program Design Report (Rev. 0)* and the *Final Dredging Program Contingency Plan (Rev. 0)*. The remedial design report contained the basis of design, calculations, technical specifications, engineering drawings, and operation and maintenance plans. The contingency report identified responses to upset conditions that may be encountered during implementation of the remediation activities.

In March 1996, EPA provided RMC with comments on the *Final Dredging Program Work Plan (Revision 1)* and approved the *Braced Sheet Pile Design Report*. RMC met with EPA in April 1996 to address EPA's concerns and resolve comments on the work plan. During the April meeting, RMC and EPA decided that a section of the St. Lawrence River referred to as Area A could be used to determine the technical limitations of dredging in meeting cleanup goals. The results from dredging Area A were to be used to define the limits of excavation in the remainder of the final dredging program.

Following the April meeting, RMC submitted a dredging plan (*Area A Operations Plan*) and a plan for sediment sampling in Area A (*Area A Sampling and Analysis Plan*). The pre-dredging sampling would establish a baseline for determining the effectiveness of dredging in Area A. After reviewing the sampling plan for Area A, EPA requested that additional samples also be collected from Area D in the St. Lawrence River. In the fall of 1996, RMC's contractors collected and analyzed sediment samples from areas referred to as Areas A, B, and D.

In December 1996, RMC submitted the *Final Report for Sampling and Analysis for the River Remediation Project* describing the results of the fall 1996 sampling. The sampling more closely defined the areas exceeding the 1 ppm cleanup goal. Also, the immunoassay procedure was determined to be suitable for delineating areas with sediment PCB concentrations less than 1 ppm.

Following submission of the December 1996 report, RMC awaited EPA action on the requested changes to the ROD. EPA revised the ROD in September 1998 to incorporate the requested changes and also required that sediment contaminated at greater than 500 ppm PCBs be treated. Based on the fall 1996 sampling, RMC revised its estimate of the volume to be dredged from 51,500 yd^3 to 77,600 yd^3, of which approximately 4,500 yd^3 would require treatment (due to expected PCB contamination >500 ppm)

In the spring of 1999, RMC and EPA met to discuss plans for completing the final dredging program. A key issue discussed during this period was a method for determining when dredging was complete. As a result of the discussions between RMC and EPA, the flow sheet logic (a flowchart) for determining when dredging is complete was developed. In addition, the plan to use Area A to determine the technical limitations of dredging was dropped.

After reaching agreement with RMC on the decision-making flowchart for determining when dredging is complete, EPA submitted comments to RMC on the previously submitted river remediation work plan and design documents. EPA requested that the design documents be updated to reflect activities completed after the design documents were submitted in 1996. EPA also requested that the Quality Assurance Project Plan (QAPP), Safety and Health Plan (SHP), and Contingency Plan be updated. Additionally, RMC agreed to prepare a stand-alone monitoring plan for submittal.

A revised work plan (Rev. 2) and design report (also Rev. 2) were transmitted to EPA in February 2000. Following the receipt of agency comments and a meeting between RMC, EPA, NYSDEC, the St. Regis Mohawk Tribe (SRMT), and Environment Canada in April 2000, both documents were again revised. The *Final Dredging Program Work Plan (Rev. 3)* was submitted to EPA in May of 2000, as was the *Final Dredging Program Design Report* (Rev. 3). EPA approved these documents in correspondence dated June 23, 2000, at which point in time the procurement and construction planning activities began for the remedial action work completed in 2001. Construction of onshore support facilities, including the sediment storage area, and east dock, began in the late summer and continued through the fall of 2000.

Also in August 2000, RMC submitted the Final Dredging Program Remedial Action Work Plan (RAWP) (Rev. 0). Comments on this document were received in February and March 2001. A meeting was held at the RMC plant in March 2001 involving EPA, the U.S. Army Corps of Engineers, NYSDEC, the SRMT, and Environment Canada to discuss the comments and proposed changes to the RAWP. Following the approval of proposed changes, a revised RAWP was submitted in early June 2001. EPA approval of the RAWP was obtained later in the month, just prior to the start of dredging.

Figure 2-8 presents a timeline of the key deliverables and regulatory decisions for the St. Lawrence Remediation project. Additional details regarding the content of the deliverables was presented in the previous section.

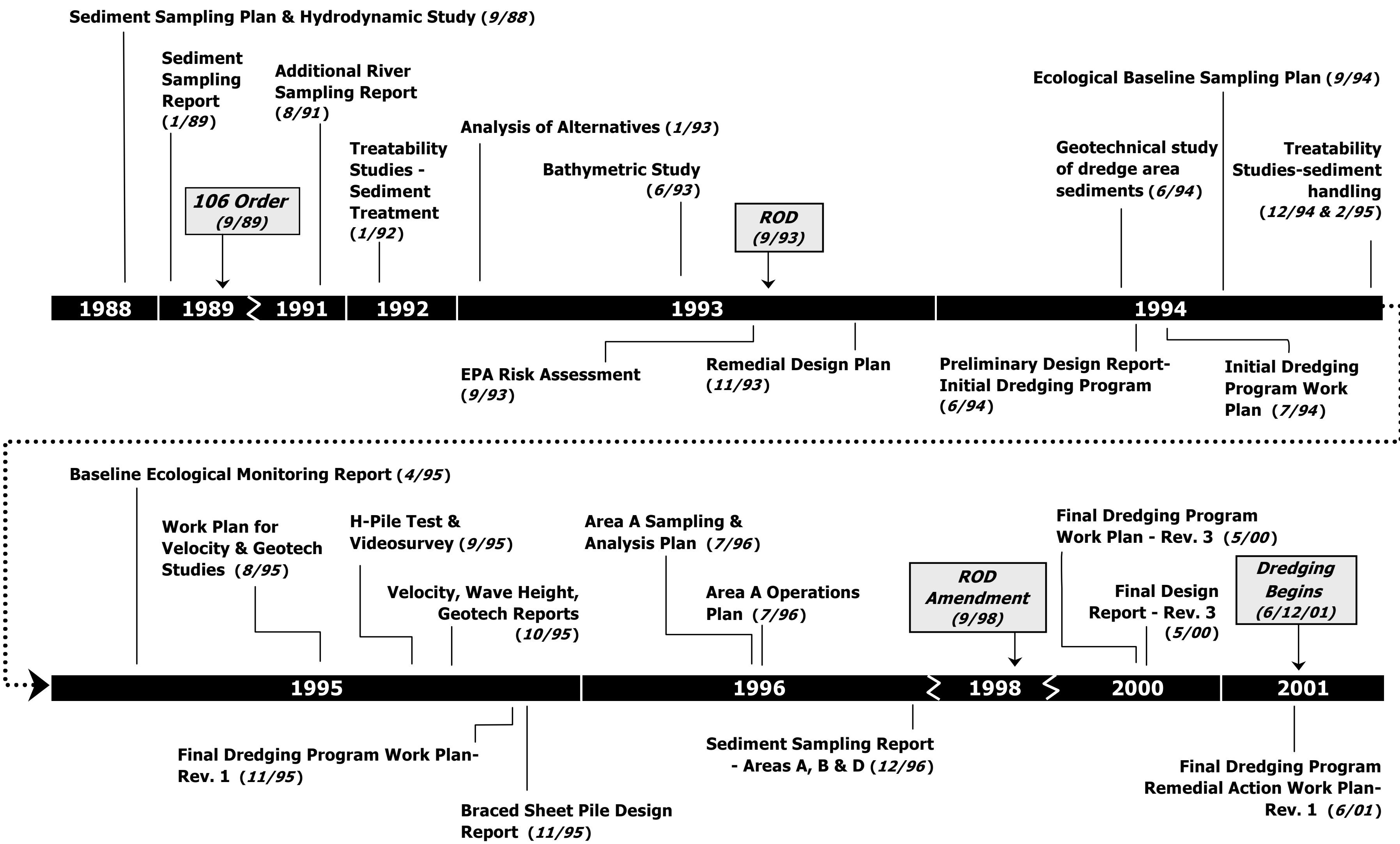


Figure 2-8
Timeline of Key Deliverables and Regulatory Drivers for St. Lawrence River Remediation Project

3.0 REMEDIATION PROCESSES

This section describes the work accomplished prior to and during the 2001 remediation activities.

3.1 CONSTRUCTION OF ON-SHORE SUPPORT FACILITIES

Following the receipt of EPA approval on the Final Dredging Program Remedial Design and Work Plan on June 23, 2000, planning and mobilization efforts for the construction of onshore facilities needed to support the river remediation work began. The following discussion summarizes these construction activities, looking first at those completed in 2000 and then those completed in the 2001 prior to the start of the sheet pile installation activities. Figure 3-1 presents a summary schedule showing the duration of all construction and remediation activities completed for the project.

3.1.1 Year 2000 Construction Activities

Site work began in August 2000. Also in August, work began at the Faust Corporation yard in Detroit on modifying the material barges that were eventually used as dredge scows. The initial work at the site involved the clearing and grubbing of the onshore areas associated with the East Dock, Sediment Storage Area (SSA), and access roads.

In September, the bid packages for the East Dock steel sheet piling and impermeable liners (60-mil geotextile) for the East Dock and SSA were prepared and transmitted to potential bidders. Other materials also were procured and delivered to the site, including stone for the East Dock, SSA and access roads. Excavation work continued throughout September for roads, berms, sumps and drainage systems in the SSA. An auxiliary storage pad for landfill materials was also constructed.

In October, the bid packages for asphalt paving and security fencing for the SSA were put out for bid. Piping and catch basins for drainage controls in the SSA were installed, and the SSA retention basins were excavated (the basins were used to store water prior to treatment in the temporary water treatment plant constructed in 2001 on the SSA). The base for construction of the East Dock was also prepared. Beginning on October 18 and continuing through November 10, the sheet piling for the East Dock was installed (Figure 3-2). After placement of the sheet pile, the interior was backfilled with stone, followed by a 6-inch layer of sand, an impermeable liner, and a 12-inch layer of compacted stone.

Following the completion of grading work in the SSA, a geotextile filter fabric was laid down, followed by the 60-mil liner, and then another layer of geotextile (Figure 3-2). Above this upper fabric layer, 3 inches of crushed stone were placed, in preparation for the asphalt paving of the entire 4.6-acre SSA.

In November, the light fixtures and power outlets for the SSA and access roads were installed, the SSA was paved with a 2-inch layer of asphalt, and the concrete pad for the SSA truck scale was installed. In addition, security fencing was installed around the perimeter of the SSA. The first pair of material barges, the 800-ton “147” and “148” barges, arrived at the site from Detroit. The barges were moored near the mouth of the Grasse River for the winter.

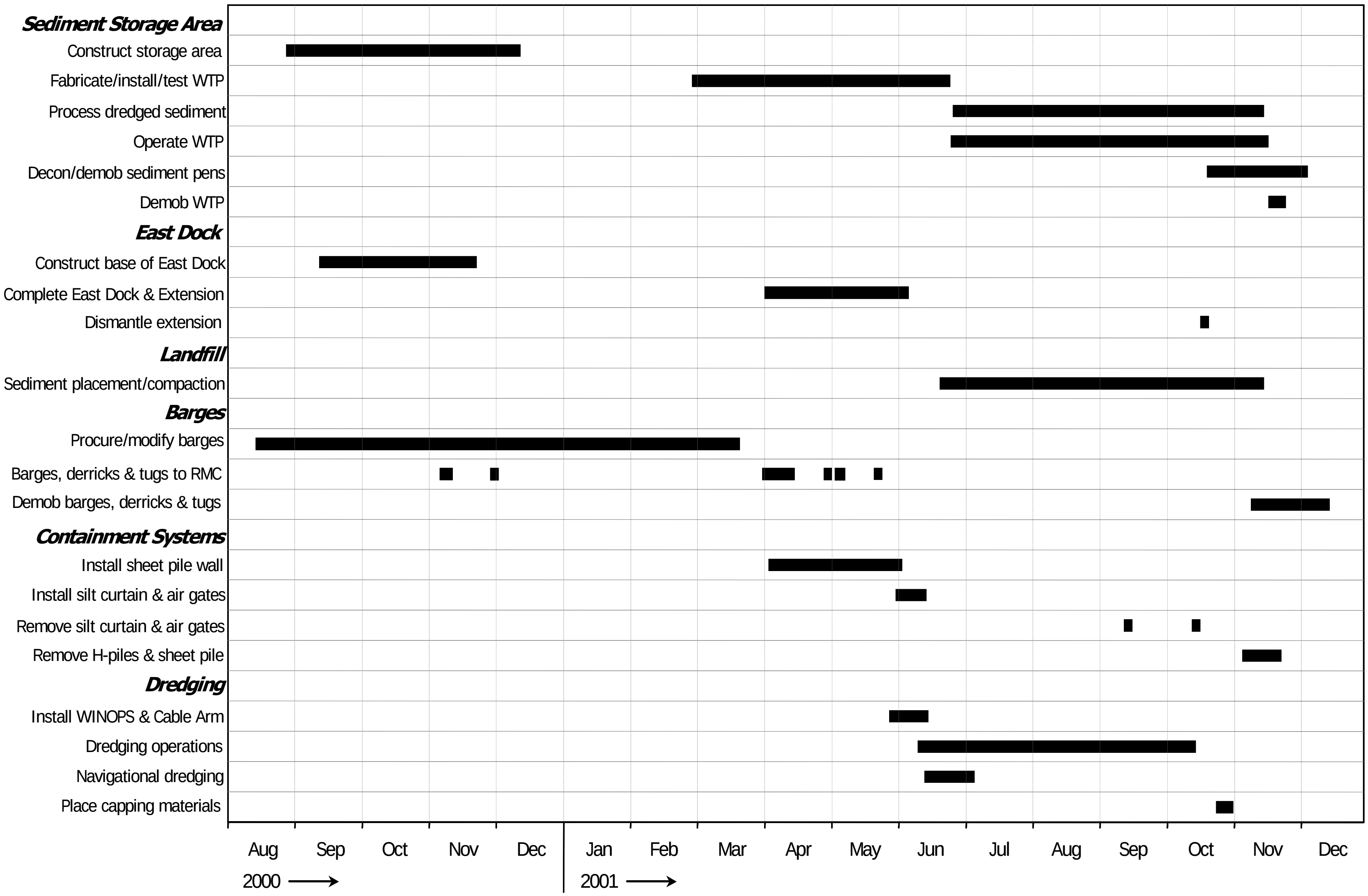


Figure 3-1
Summary Schedule For Remediation Activities

Figure 3-2
Installation of East Dock Sheet piling and Construction of Sediment Storage Area

Construction work ended for the year in early December, following the delivery and placement of the jersey barriers used in the SSA to define the 17 sediment pens constructed for temporary storage of dredged sediment. Fourteen of the 17 pens were eventually used for sediment dewatering, stabilization, and temporary storage; these 14 pens had approximate dimensions of 65 ft × 52 ft, for a total area of 2.8 acres.

Two derrick barges, the “Comanche” and “IV-Spot” along with the small tug “Linhurst” also arrived at the site in December. These vessels were moored for the winter at the Seaway docks below the Snell Lock. The St. Lawrence Seaway closed down for the winter on December 22, 2000.

3.1.2 Year 2001 Construction Activities (On-Shore)

The major activities during the initial months of 2001 were related to procurement. Bid packages were prepared and proposals were evaluated for the H-beam (“king”) piles, sheet piles and related steel materials for the sheet pile wall; the silt curtains; the environmental clamshell buckets; electronics for the dredge performance monitoring; and water treatment plant. Final preparation work continued on the SSA, East Dock, access roads and associated facilities. A large part of the effort beginning in February and continuing through May concerned the delivery of materials and mobilization of equipment needed for the remediation project. Highlights of these activities are presented below.

Delivery of the large quantity of steel for the sheet pile wall began in early February and continued through the end of March. An existing equipment storage/material lay-down area near the West Dock was rehabilitated for the temporary storage of the steel. Also in February, Cable Arm began fabrication of the 5 environmental clamshell buckets; the buckets were delivered in mid-May.

In March, Enprotec began fabrication of the water treatment plant and Elastec began fabrication of the silt curtains. The water treatment plant was delivered to the site, set up and began initial testing in late April. The silt curtains were delivered in late May. Also in March, the river dewatering beds were cleaned and rehabilitated for use in 2001. Plans were also finalized for establishing contaminant exclusion zones and decontamination areas in compliance with CFR 1920.120.

In early April, offloading of steel continued and fabrication of the air gates and the structural steel for the East Dock extension began. Following delivery of the steel to the site in early May, the East Dock extension was constructed. The interim storage pad on the west side of the RMC facility was prepped for use in rock washing or storage of >500 ppm material. Office trailers were installed for construction field offices in the SSA and various laydown and parking areas were also constructed. Trucks were used to deliver the sectional barges and tugboat “Cormorant” to the site. A hydraulic excavator, the “Cat 350” was also shipped to the site via truck and assembled. Work also continued on the establishment of contamination controls and decontamination facilities.

Final installation of lighting and electrical panels on the East Dock was completed in early May. The landfill access road was completed and truck ramps were fabricated and delivered for use on the SSA and landfill. The concrete pad for the East Dock was poured in early May. The pad and all other concrete surfaces used in sediment handling operations were sealed. In addition, the compressor station for the air gates was constructed as were the air monitoring stations for the background and landfill stations.

The St. Lawrence Seaway reopened March 23, 2001. The tugboat “Rochelle Kay” and service barge arrived at the site in early May, as did the 2 1200-ton material barges “140” and “141.” The 400-ton material barge “718” arrived at the site in early May as well; the derrick barge “Relief” arrived in late

May. Also in late May, assembly and testing of the electronics associated with the dredge positioning software (WINOPS) and dredge operator controls (Clamvision®) were conducted.

3.2 INSTALLATION OF CONTAINMENT SYSTEMS

A key feature of the river remediation project was the installation and maintenance of containment systems designed to isolate the remediation area from the St. Lawrence River. The system prevented the release of turbidity and/or suspended sediment generated during sediment removal activities. The system included a steel sheet pile wall that enclosed the entire remediation area; silt curtains that provided secondary containment for the more highly contaminated Area C and also isolated uncontaminated portions of Area B from the dredging areas; and air gates that created an air-bubble curtain that acted as a circulation barrier while allowing for barge and tugboat access to areas enclosed by the silt curtain and sheet pile wall.

3.2.1 Sheet Pile Wall

The steel sheet pile wall was constructed in accordance with the design drawings and specifications associated with the *Final Dredging Design Report - Braced Sheet Pile Design* (M&E 1995). The wall consisted of interlocking steel sheeting embedded several feet or more into the sediment and supported by H-beams ("king piles") driven to greater depths (Figure 3-3). The sheeting and king piles were tied together through a welded and bolted framework of steel braces and walers. Placement of the sheeting and king piles was guided by surveyors, who also confirmed through as-built verification checks that the wall was constructed along the proper alignment. A more detailed description of the wall and equipment and methods used for construction is in Appendix B.

Sheet-pile operations began April 5, 2001 and the first H-pile was set April 13, 2001. Sheeting installation began on the 20^{th} of April. The wall was completed on June 4, 2001. The finished wall consisted of 208 king piles and 2,243 sheets. Its length was 3,829 ft, extending from the shoreline on the eastern and western boundaries out to the margins of the shipping channel (Figure 3-4). The maximum depth of water along the alignment for the wall was ~32 ft.

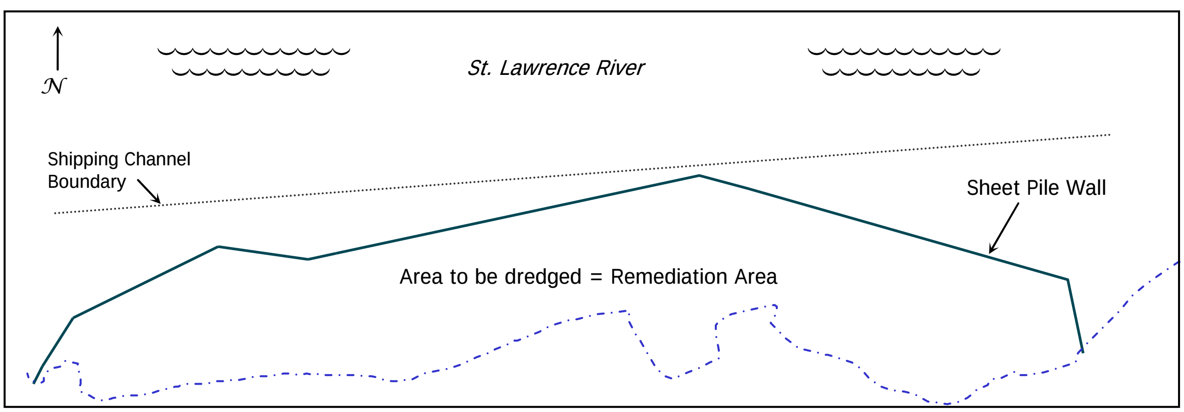


Figure 3-4
Configuration of Sheet Pile Wall and Delineation of Remediation Area

Figure 3-3
Installation of King Piles and Sheeting

After installation, a video survey was conducted to verify that there were no openings along the bottom of the wall or open seams in the sheeting. This survey identified a few small holes that were patched using sand bags. In addition, some of the sheeting was trimmed after installation to reduce the surface area exposed to wind forces.

There were no significant deviations from the design. Field modifications were required to account for variations in embedment depth as rocks and other features prevented the driving of king or sheet piles to the target depth. These variations were easily compensated for in the field and there was no impact on the integrity or final dimensions of the wall.

Environmental monitoring data show that the sheet pile wall functioned as designed and effectively contained the turbidity and suspended sediment generated during the dredging activities within the remediation area. The wall maintained its structural integrity throughout the 2001 construction season and did not require any repairs or replacements.

3.2.2 Silt Curtains

Silt curtains, consisting of 22-oz. PVC sheeting weighted on the bottom and suspended by polystyrene flotation buoys, were installed around Area C and a portion of Area B (Figure 3-5). The silt curtains were tied to H-beam anchor posts driven at a spacing of 100 ft, and anchored on the shoreline to a driven post or tree. The ballast for the curtains was a 3/8-in. galvanized anchor chain within a sealed pocket in the sheeting that could adapt to the bottom contours, thereby ensuring a complete vertical barrier. The curtain was suspended by cables attached to tensioners and anchor plates with reefing lines connected to the lower ballast chain to adjust the vertical height.

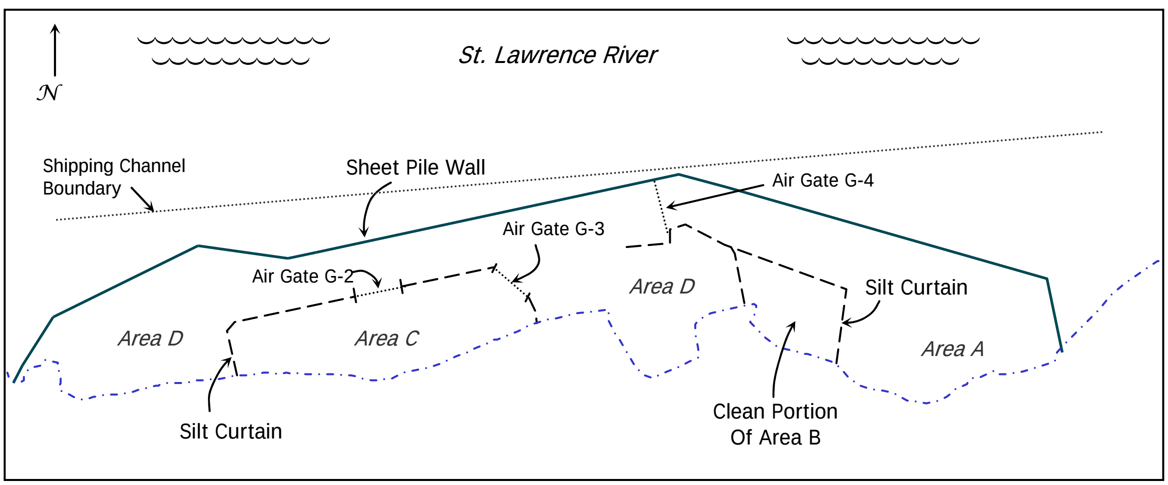


Figure 3-5
Configuration of Silt Curtains and Air Gates in Remediation Area

Silt curtain deployment began on June 2 and ended on June 129, 2001 (Figure 3-6). A total of 996 ft of curtain was used to isolate Area C; 1,222 ft was used in Area B. The alignment of the curtain was established by the surveyors, who marked locations for all of the anchor posts and shoreline anchors. The surveyors also conducted as-built checks to verify proper placement of the anchor posts. Because there were no appreciable water currents within the enclosure, the silt curtains remained in its proper position throughout the duration of the project. The curtains did not require any maintenance, repair or replacement. Additional details regarding the installation of the silt curtain, including equipment and methods used, are presented in Appendix B.

Figure 3-6
Installation of Silt Curtains

The silt curtains effectively isolated both the more contaminated Area C and prevented contamination of the clean portion of Area B. The curtains were constructed of an impermeable vinyl fabric. As long as there were no holes in the curtain and it remained in the proper position, no turbidity or water could pass through it. The performance of the curtain in isolating the clean portion of Area B was evaluated through collection of a sediment sample from inside the silt curtain on November 14, 2001. This sample contained 0.15 ppm of PCBs. Previous sampling in this part of Area B had identified 0.11 to 0.65 ppm of PCBs. The November 2001 sample showed that the silt curtains had effectively prevented the contamination of this clean area.

The Area C silt curtain (and anchor posts) was removed September 14-17, 2001 to allow for dredging of sediment along the silt curtain alignment. The Area B curtain and anchor posts were removed after dredging was completed, between October 19 and 22, 2001.

3.2.3 Air Gates

Air curtain technology was used to create vertical circulation barriers that allow boats to pass but restrict the movement of water between various parts of the remediation area (see Figure 3-5). The curtains consisted of 2-in. O.D. steel pipe fitted with diffuser orifices on a helical, 9-in. spacing (Figure 3-7). The pipes had leg supports that raised them about 1 ft off the bottom. Geomembrane was laid beneath the pipes to minimize the disturbance of nearby sediment. Divers were used to place the liner, pipe and anchors, connect the supply lines, and verify proper operation once the equipment was in place. Additional details concerning the air gates are presented in Appendix B.

A compressor station with 2 electrically driven Ingersoll Rand compressors supplied air to the gates. Air flows were approximately 993 cfm, with flow pressures of 90 – 100 psig. The compressors were connected to the air gates using thick-walled (200 psi) 3-in. PVC piping. The system was designed such that one electric compressor was a standby with a backup diesel compressor to be used when power outages occurred, which happened on 2 occasions. The air gates were operated 24 hours a day, 7 days a week between June 15 and October 12, 2001 (gates G-2 and G-3 were removed in late September; gate G-4 operated up until the last week of dredging).

The gates allowed for barge transit and limited the migration of turbid water across the barrier. The lower photo in Figure 3-7 shows an operational gate, visible as the line of bubbles on the water's surface between the two derrick barges in the photo. A detailed evaluation of air gate performance was difficult given the fact that dredging was often occurring on both sides of the gates. In one isolated incident, a small section of the geomembrane underlying the air curtain was caught by the dredge, but this incident did not affect the performance of the air curtain or the underlying geomembrane. Figure 3-8 presents turbidity data collected from inside the sheet pile wall from 2 stations associated with air gate G-3, on the eastern side of Area C.

The data show that a turbidity contrast was often present across the barrier. In July, when dredging was occurring in Area C but not in the eastern portion of Area D (Area 2D), the turbidity was consistently higher inside the air gate (i.e., within Area 2C). Later in August, dredging continued in Area C but also began in Area 2D, which obscured the pattern and in some cases reversed the contrast such that higher turbidity was found outside the gate.

Figure 3-7
Air Gate Components and Appearance During Operations

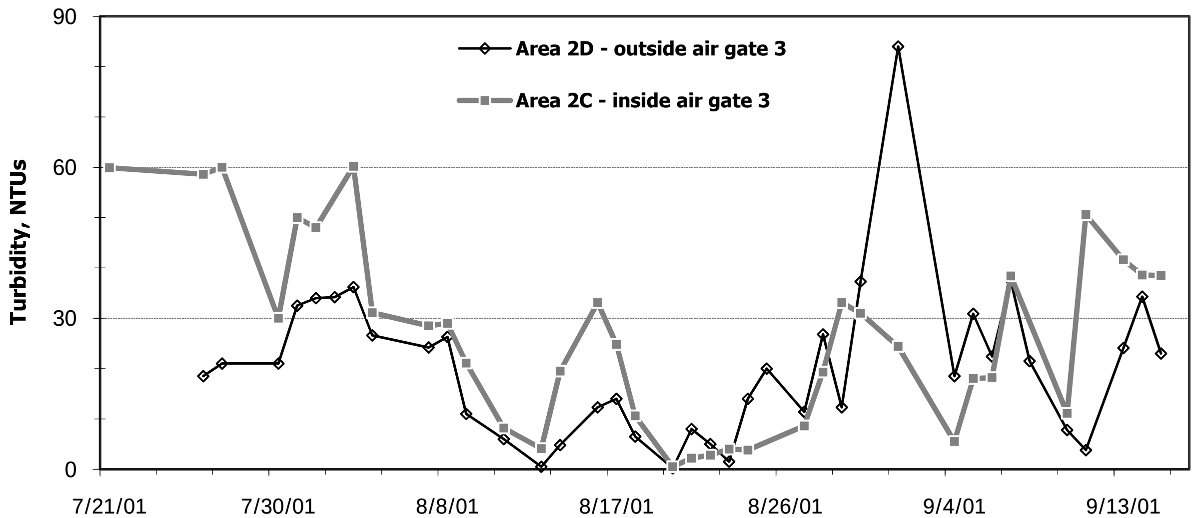


Figure 3-8
Turbidity Contrasts Across Air Gate G-3

These data indicate that the gates maintained a circulation barrier that restricted the flow of turbid water, in either direction across the gate. A major objective of the gates was to contain the turbidity generated during the removal of Area C sediment. The gates accomplished this objective and otherwise functioned as designed for the duration of the project.

Turbidity plumes did occasionally migrate across the air curtain barrier, due largely to difficulties in moving or positioning barges. These occurrences were isolated incidents and not indicative of routine operations, and the overall impact on air curtain performance was relatively minor, as measured by the verification sample results from dredge cells in the vicinity of the air gates.

3.3 SEDIMENT REMOVAL

A detailed discussion of the equipment, procedures, performance-monitoring and record-keeping activities for the sediment removal process is presented in Appendix B. The following subsections present a summary of this information.

3.3.1 Dredging Equipment

3.3.1.1 Derrick Barges

Faust Corporation supplied three derrick barges for use as dredges on the project: the *Relief*, *Comanche*, and *Ryba IV Spot*. Each dredge was outfitted with a lattice boom crane, two spuds, and an equipment doghouse (Figure 3-9). Additional modifications, involving configuring the cranes to use the Cable Arm® environmental clamshell buckets (described below) and mounting the instrumentation and wiring for the global positioning systems, WINOPS, and Clamvision® systems, were completed after the sheet pile installation activities were completed and prior to the onset of dredging activities. Additional photographs of each derrick barge configured for dredging are shown in Appendix F.

As described above, a Caterpillar Material Handler, Model 350 (Cat 350), mobilized to the site for use on the East Dock to unload sediment from material barges, was configured as a derrick barge by placing it on a flat-deck barge equipped with spuds for installation of sheet piling. At the onset of dredging, the Cat

350 derrick barge was fitted with a grappler and used to remove boulders, cobbles, logs, and other debris that interfered either with navigation or sediment removal. Fitted with a hydraulically-operated clamshell (2.5 yd^3 capacity), the Cat 350 was used to excavate contaminated sediment from the shoreline in Area C and reconfigured as a derrick barge to dredge contaminated sediments during the final week of dredging. It was also used to place the capping materials once the dredging was completed. Photos of the Cat 350 with the grappler and clamshell are in Appendix F.

Figure 3-9
Faust Derrick Barges

3.3.1.2 Material Barges

Material barges were modified at the Faust Corporation yard in Detroit during the fall/winter of 2000/2001. Each material barge was modified by the addition of a steel sediment containment pen Modifications were also necessary to make the barges seaworthy and fulfill St. Lawrence Seaway requirements. A complete description of the barge modifications is presented in Appendix B; the following discussion focuses on the components related to use of the barges as scows for handling dredged sediment.

A total of five barges in three different sizes were used for the project; each was identified by number: Barge 718 was rated as a 400 ton barge; Barges 147 and 148 were rated at 800 tons; and the largest barges, 140 and 141, were rated at 1,200 tons. Table 3-1 provides dimension for each barge.

Table 3-1
Material Barge Dimensions

Barge	Rating (tons)	Overall Dimensions Length *x* Width (ft)	Sediment Pen Length *x* Width (ft)	Sediment Pen Area (ft^2)
718	400	128 × 32	98 × 22	2,156
147	800	131 × 34	100 × 25	2,500
148	800	131 × 34	100 × 25	2,500
140	1,200	165 × 42.5	124 × 35.5	4,402
141	1,200	165 × 42.5	124 × 35.5	4,402

Figure 3-10 shows the barges in use as scows for holding sediment during dredging. The sediment containment pens were constructed using a 5/16-in. steel plate wall, supported along its perimeter by structural steel knee braces. A 6-in. × 6-in. steel tube was welded to the top of the pen wall for lateral support and protection against heavy equipment contact. The deck of each pen consisted of a concrete floor reinforced with 6 × 6 woven wire mesh and # 4 rebar attached to Nelson Studs™ welded to the deck. All concrete decks were sealed before being placed in service.

The end of each sediment pen contained a specially-constructed sand filter system designed to allow for drainage and filtering of free water from the sediments. The wall separating the sediment pen from the filter system had two or more large openings covered with steel bar grating on the surface toward the sediment pen, designed protect the inner layer of the screen from damage from rocks, dredge buckets and sediment removal equipment. Behind the grating was a barrier consisting of plastic Wedgewire™ filter screen panels with 0.010-in. slots. The Wedgewire screen was designed to filter out large particles prior to the water entering the sand filter. Filter fabric was placed on the back of the Wedgewire (i.e., toward the sand).

The sand bed consisted of a nominal 18-in.-thick layer of uniformly graded sand selected on the basis of filtration tests in the Faust yard while barge modifications were underway. Water and suspended solids passing through the screens and filter fabric was filtered as it passed downward through the sand toward the underlying drainage network. These drains consisted of slotted PVC drainage pipe connected to piping placed into recessed trenches below the sand. Piping and a valve were provided to allow discharge of filtered water over the side into the dredge pool. The RAWP required that the discharge be stopped when transiting "clean" or "no-dredge" areas.

Figure 3-10
Cable Arm Bucket (top) and Conventional Rock Bottom

The material barges and sand filter systems performed as designed; however, the sediment was much less free-draining than anticipated, which resulted in the unloading of material with high water content (see Section 3.5). Monitoring of the turbidity of the discharge water from the sand filters was conducted to track the performance of the filter sand but the rate of percolation through the sand was found to be the driver for change-out of the sand media. The filter systems required regular maintenance to remove layers of fines across the top of the sand and frequent change-outs of the sand were conducted when drainage was slow. In addition, the filter fabric layer across the back (sand) side of the Wedgewire screen was eventually removed to facilitate better drainage from the sediment pens into the filter beds.

3.3.1.3 Cable Arm Buckets

Cable Arm, Inc. supplied four Cable Arm® environmental clamshell buckets (Cable Arm buckets) specifically designed for the removal of contaminated sediment while minimizing turbidity and water content in the dredge spoil. The *Final Dredging Program Work Plan*, *Rev. 3* (Bechtel 2000) contains the rationale for selecting the Cable Arm bucket and further explains its design and operation.

Two 5.4-yd^3, one 3.5-yd^3, and one 2-yd^3 Cable Arm buckets were utilized on the project (Figure 3-11). Each bucket was equipped with sensors (see below) to allow the operator and marine technician to monitor its position with respect to both the water-air and water-sediment interfaces. The buckets have a specialized closing system that allows it to close along a constant horizontal plane, a key feature in the determination of depth of cut.

Each Cable Arm bucket was outfitted with one or two depth sounders (depending upon bucket size), a pressure transducer and three pressure switches that provided data for determining the vertical position of the bucket, depth of cut, and verification of closure, respectively. Depth sounders used sonar echoes to determine the height of the bucket off the top of the sediment. Sounders were calibrated so that depth readings corresponded to the cutting edge of the bucket. The sounders read “0” when the cutting edge of the bucket was on top of the sediment. A negative sounder reading indicated the distance of bucket penetration into the sediment, which corresponds to the depth of cut.

The pressure transducer reading indicated the distance the instrument was below the top of water. The transducer, like the depth sounders, was calibrated with an offset so that the depth reading corresponded to the cutting edge of the bucket. The accuracy of the pressure transducers was within +/- 0.02 ft (0.24 in.).

Pressure switches were mounted on the side of the bucket to show the bucket’s open/closed status. One closure switch indicated that the bucket was fully open. This was important so that the offset corrections for the depth sounders and pressure transducer were accurate as the bucket entered the sediment. Closure pressure switches indicated full closure of the bucket and were mounted on opposite sides of the bucket.

The sounders, transducers and pressure switches transmitted data through an electrical umbilical to the Clamvision® system mounted in the crane. The Clamvision® system converted analog data from the sensors into a digital signal, which was then transmitted to the marine technician for input into the WINOPS® software.

Figure 3-11
Cable Arm Environmental Clamshell Buckets at Delivery and in Use for Dredging

The Cable Arm buckets generally performed as expected. The mechanical components of the buckets had relatively few problems in comparison to those associated with the sensors and associated wiring systems. These problems were resolved through repairs and replacements in the field, but operational time was lost.

During the initial dredging activities, it was discovered that the Cable Arm buckets could not be re-opened when submerged below depths of 6 ft or more. The buckets were modified with counterweights to allow for re-opening as required in the dredging operations procedure in the design and work plan. Representatives of Cable Arm completed these modifications during the initial weeks of the environmental dredging activities.

The large quantity of fractured rock (long, straight edges vs. rounded cobbles) associated with the dredge spoils presented a unique problem for the Cable Arm buckets. The Cable Arm bucket lacked sufficient power to shatter these rocks, and they were not easily moved through the sediment, which complicated the operator's procedure for dredging and ultimately led to a revision of the procedure (see Appendix B).

In some cases, after removal of the overlying soft sediment, a hard bottom condition with a very thin layer of soft sediment or a mixture of rock and fine sediment remained with contamination above cleanup goals. A known limitation of the Cable Arm technology was its inability to remove sediment in areas with hard bottom conditions, such as glacial till or stiff clays, which it was unable to penetrate. This limitation eventually led to the decision to use alternative dredging methods using a conventional, crane-mounted clamshell bucket and a hydraulically-operated clamshell mounted on the Cat 350. These alternative dredging techniques are discussed below.

3.3.1.4 WINOPS

WINOPS® dredge positioning software interfaced the bucket sensor data with differential global positioning systems (DGPS), tide gauge and bathymetric data in order to provide real-time monitoring and archiving of these parameters in an electronic format. A complete description of the components, features, and procedures for the system is presented in Appendix B.

WINOPS® received the digital signals from the Clamvision® system and presented the sounder, transducer and closure status of the bucket along with the orientation and location of the barge, its derrick, and bucket position superimposed on the base map on the computer screen. DGPS data was converted by WINOPS® to State Planar Coordinate System (1983 North American Datum 1983), allowing for correlation between real-time barge/bucket location and maps of the dredging area.

WINOPS® determined the barge orientation and position by calculating the DGPS signal from two NovAtel® antennas that were located on the barge. These antennas had an accuracy of one meter. One antenna was mounted on the tip of the derrick above the holding line and thus was aligned with the center of the Cable Arm bucket. A differential correction signal, generated by a similar antenna mounted on top of the base station field trailer, allowed for an accuracy of ±20-centimeters for the bucket-center location. A radio modem transmitted the DGPS signal from the base station to a receiver on each derrick-barge at one-second intervals.

A Caplan Tide Gauge® measured the water elevation (tide) at the East Dock and transmitted the tide elevation via radio transmitter to the radio modem at the base station. In turn, the tide elevation was transmitted to the barges with the differential correction GPS signal at one-second intervals.

The WINOPS® software allowed for archival of the dredging data, which consisted of the bucket sensor inputs (sounders, transducers, pressure switches) and bucket position (from the DGPS system). The marine technician, by pushing the F12 key, marked the bucket location on the computer screen. The bucket sensor data along with the bucket coordinates were automatically written to an electronic file. Additional information concerning the content, storage, processing, and manipulation of these data is presented in Appendix B.

The WINOPS system generally performed as expected. One limitation of the system is that, like all software, it only works when the input data are valid, usable data. There were a number of problems with the sounder and transducer data, needed to define the depth of cut for each bucket. These problems were not related to WINOPS, nor even to the sounders and transducers, but rather to the conditions under which the instruments were collecting data.

For example, dredging in shallow water, in turbid water, and in areas where thin layers of low-density sediment were underlain by a layer of high-density sediment often generated erroneous depth of cut data. In addition, although aquatic vegetation was removed prior to the start of the dredging activities, it may have impacted depth of cut data collected at the end of the dredging program, primarily in Area A, where it had begun to grow back by the end of summer. Damaged instrumentation or excessive vibrations also generated erroneous data. All of these readings were duly recorded by the WINOPS system and had to be purged through a manual review of the files. These data complicated the documentation of the dredging process, and in some cases prevented the resolution of an accurate depth of cut for portions of a dredge cell.

3.3.1.5 Record Keeping

The technicians on the derrick barges kept track of the dredging process through two types of records. The first was a written journal of the activity aboard a derrick barge including a record of the times that events happened. The journals typically kept track of the maintenance that was performed on the rigs and the WINOPS system, and they also typically kept track of the material barge movements. The technicians also kept log sheets that recorded each dredge bucket cut (“bucket logs”). Information on the bucket logs included the time the bucket was collected, the cell the bucket was taken from, the closure status of the bucket, and typically (but not always) an estimate of the volume of material in the bucket.

3.3.2 Dredging Process

Dredging activities were conducted under two broad categories: navigational dredging and environmental dredging. Navigational dredging was completed during the initial phase of the dredging while environmental dredging continued through mid-October; both are described below.

3.3.2.1 Navigational Dredging

Navigational dredging was conducted to allow for barge and tugboat passage in Areas A, B and D. Navigational dredging entailed the removal of sediment (and rocks and boulders, if necessary) to provide for sufficient water depth to accommodate the draft of the vessels. High spots requiring navigational dredging were identified on the basis of previous bathymetric surveys, additional depth surveying during sheet pile wall installation using the ATL bumper apparatus, and field efforts to mark areas where the tugboats or barges actually struck underwater obstructions or were grounded.

Navigational dredging began on June 12 and continued on an intermittent basis through July 6, 2001. The dredging was accomplished using the Cable Arm bucket, conventional rock bucket, and hydraulic grappler mounted on the Cat 350, depending on bottom conditions (Figure 3-12).

Figure 3-12
Navigational Dredging with the Conventional Rock Bucket (top) and Cat 350 Grappler

The grappler was used to remove large rocks and boulders, trees, and assorted debris (e.g., wooden piers). All of the sediment was handled as material with <50 ppm contamination, even though much of it was obtained from areas—or depths—shown to be clean during earlier sampling activities.

The sediment and wooden debris were transported to the onsite landfill for disposal. Large rocks and boulders were processed through the rock washing station and disposed of at the onsite quarry after visual inspection to verify that all sediment had been removed. Additional details concerning navigational dredging are provided in Appendix B.

3.3.2.2 Environmental Dredging

Environmental dredging entailed the removal of sediment with contamination above the ROD-based cleanup goals. Environmental dredging involved several discrete tasks, including hot spot removal, the design cut (initial or first pass dredging), redredging (second pass, third pass, etc.), and use of alternative dredging techniques in areas with persistent sediment contamination. Figure 3-13 presents representative photos of environmental dredging activities.

A cell status report, presented in Appendix C, was developed for use during the environmental dredging activities. The cell status report provides the dredging and verification sampling history for all 268 dredge cells.

Hot Spot (>500 ppm PCBs) Removal

During the design and planning stage of the project, 8 hot spots were identified in association with historical sampling results showing PCBs greater than 500 ppm (Figure 3-14). All 8 of the hot spots were located in Area C, mostly in proximity to the former outfall 001. Additional sampling conducted in April 2001 identified a 9th hot spot in the eastern portion of Area D. Additional hot spots were identified during other dredging activities and are discussed in detail in Section 6.1.1.5. Each of the 9 hot spots identified prior to dredging were defined by delineating a 50-ft square centered on the sampling point that yielded the >500 ppm sample. The intent with this delineation was based on the expectation that the hot spots represented discrete accumulations of more highly contaminated sediment that were limited in areal extent; dredging a 2,500 ft square area was expected to provide a high level of confidence that all of this more highly contaminated material would be removed. Hot spot coordinates are shown in Table 3-2.

Table 3-2
Hot Spot Coordinates and Target Depth of Dredging

Hot Spot	Northing	Easting	Target Depth (in.)
HS-1	2242083	427060	8
HS-2	2242135	427111	24
HS-3	2242106	427118	32
HS-4	2242058	427253	8
HS-5	2242181	427316	32
HS-6	2242221	427512	16
HS-7	2242153	427563	16
HS-8	2242211	427597	16
HS-9	2242246	427982	8

Figure 3-13
Environmental Dredging Activities

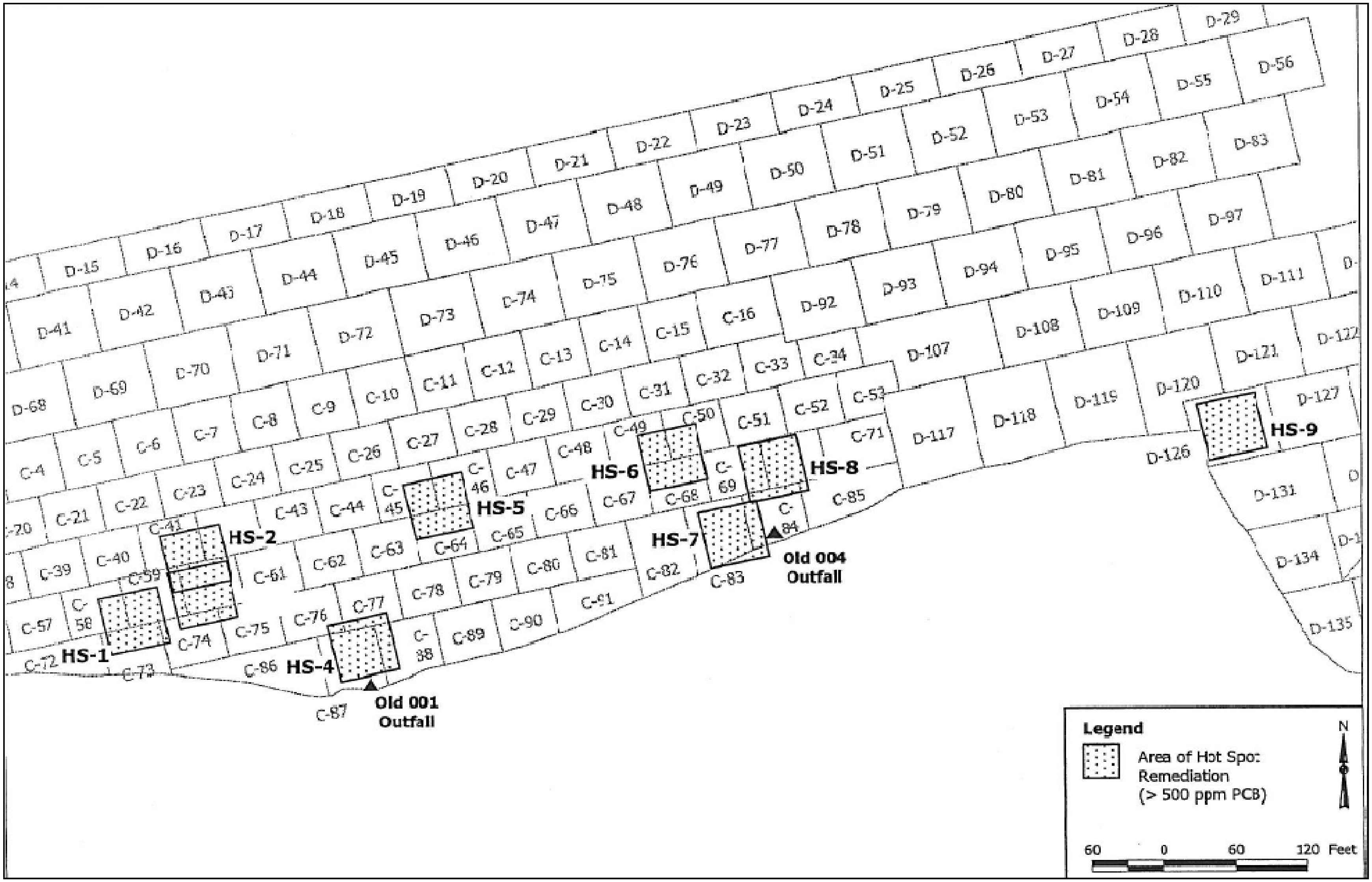


Figure 3-14
Location of Hot Spots

The hot spots were dredged between July 2 and August 1, 2001. The initial dredging of each hot spot was completed using the Cable Arm bucket. Approximately 670 yd^3 of sediment were removed from the hot spots with the initial pass. Target depths of dredging for the hot spots, defined as the maximum depth where the >500 ppm material was identified, varied between 8 and 32 in.

Verification sampling results from the center sampling point of each hot spot showed that concentrations were below 500 ppm in all 9 hot spots. WINOPS data collected during dredging identified obstructions in portions of several of the hot spots where the target depth of excavation was not attained. Biased samples were collected from these areas in 5 of the hot spots. Contamination >500 ppm PCBs was identified in HS-4, which resulted in a second dredge pass with the Cable Arm bucket. This second pass yielded very little sediment (50 yd^3). Verification samples after the second pass with the Cable Arm bucket showed that contamination remained above 500 ppm in the northern and western portions of HS-4.

For the third dredge pass at HS-4, a temporary gravel pad was built out from the shore so that the hydraulic clamshell of the Cat 350 could be used. The excavation limits for the hot spot were expanded approximately 10 ft to the west and north to assure removal of all contaminated sediment. The CAT 350 also excavated at least one foot into the underlying hard bottom (till), and in some cases the over-excavation was more than a foot. Because of this expanded area and deeper excavation, approximately 330 yd^3 of sediment were dredged from this area alone. Samples collected after excavation with the Cat 350 showed that this third attempt to remediate HS-4 was successful.

All 9 of the hot spots received at least one more dredge pass as part of the Area C or Area D sediment removal efforts, including HS-4. In some cases, the cells associated with the hot spots received several more dredge passes based on persistent contamination in the verification samples.

Design Cut (First Pass)

First pass (environmental) dredging was completed in all 268 dredge cells, beginning with cell A-34 on June 15 and ending with cells A-27 and A-28 on October 5, 2001. Table 3-3 summarizes first pass dredging dates for each subarea. First pass dredging (involving 268 dredge passes) removed approximately 63,270 yd^3 of sediment (wet) and 13,404 lbs of PCBs (mass and volume calculations are discussed in Section 3.3.3). Based on the results of verification sampling, a total of 134 cells were successfully remediated after the first pass (see Section 6 for a complete discussion of verification sample results, and remediation effectiveness).

Table 3-3
Schedule for First Pass Dredging

	1A	1B / 2B	2C	2D	3C	3D
First pass start date	15-Jun	17-Aug	17-Jul	24-Jul	17-Jul	28-Jun
First pass completed	5-Oct	17-Aug	22-Sep	24-Sep	19-Sep	17-Sep

Appendix B presents the WINOPS screen shots showing the bucket pattern for first pass dredging in each of the 268 dredge cells. The figures also show the locations of obstructions, typically rocks, boulders, or other features that prevented the closure of the bucket, and also identify areas with hard bottom conditions, defined as areas that did not have any soft sediment that could be removed using the Cable Arm bucket. The screen shots show the areal coverage of dredging, and document that dredging was attempted in 100 percent of the area of all 268 dredge cells.

The objective of first pass dredging was the removal of sediment to the target depth of dredging as defined in the design and discussed in greater detail in Appendix B. Plate 1-1 in Appendix B shows the target depth of dredging in all 268 dredge cells. Target dredging depths were identified as 0-8 or 0-16 in. in Areas A and D, and all soft sediment up to a maximum depth of 24 in. in Area C, except where otherwise noted on Drawing 03000-102-R11 (*Dredge – Grid and Depth*) from the design. These alternative target depths, typically 32 to 35 inches, were primarily associated with the >500 ppm hot spots discussed above.

As discussed above, the Cable Arm buckets were configured and operated to take an approximate 11-in. cut. Thus dredge cells with a maximum target depth of 8 in. would receive a single bucket pass, which would result in an 11-inch cut. Cells with a 16-in. target received two bucket passes, resulting in a 22-in. cut. Three bucket passes, resulting in a 33-in. cut, were needed for Area C cells where the maximum target depth was 24 in.

This conservative pattern of over cutting the target depth of dredging was intended to make sure that all contaminated sediment was removed, reducing the likelihood that additional dredge passes (redredging) would be needed. The actual depth of excavation during the first pass was closely tracked using the WINOPS and Clamvision systems described earlier. The equipment, methodology, and data collection techniques are described in Appendix B; the results are summarized below.

Depth of cut data were collected from the pressure transducers and depth sounders mounted on each bucket as described above. These data showed that the average depth of cut after the first pass met or exceeded the maximum target depth of dredging in the majority of cells. The significance of this finding was reduced somewhat by the large amount of redredging that was required. Fully one-half (134) of the dredge cells required more than one dredge pass, and about 40% of these had to be dredged again, in some cases many more times; redredging by area is summarized in Table 3-4

Table 3-4
First Pass Dredging Summary by Subarea

	Number of Cells in Each Area						
	1A	**1B / 2B**	**2C**	**2D**	**3C**	**3D**	**Total**
First pass only	26	2	23	57	12	14	134
2 or more dredge passes	9	0	32	23	24	46	134
Percent with ≥ 2 passes	*26%*	*0*	*58%*	*29%*	*67%*	*77%*	*50%*

Resolution of the final depth of cut had to consider the additional sediment removed during the redredging activities. As the number of dredge passes increased, resolution of this number became increasingly complicated due to limitations with the instrumentation and equipment; Appendix B provides additional details. Because of the need to incorporate all dredge passes into the evaluation of whether the design depth was attained, a separate section that discusses the final depth of cut is presented below, after discussion of the redredging and alternative dredging methods.

Redredging

Redredging was conducted in 134 dredge cells, whenever verification sampling results indicated contamination levels remained above the ROD-based action levels. Second pass dredging began on August 4 and redredging ended with the 6th and 9th dredge passes on Cells C-45 and C-60, respectively, on October 16, 2001. The cell with the greatest number of dredge passes, C-44, received its 10th and final dredge pass on October 13, 2001. Due to logistical considerations, redredging was initiated in certain parts of the site before first pass dredging was completed in all areas. The schedule for redredging activities is presented in Table 3-5. Additional information concerning the equipment and procedures used for redredging is presented in Appendix B.

Table 3-5
Schedule for Redredging

	1A	2C	2D	3C	3D
Start Redredging (*2nd pass*)	26-Sep	25-Aug	4-Sep	24-Aug	4-Aug
Redredging completed (*nth pass*)	13-Oct	16-Oct	13-Oct	16-Oct	19-Sep

Note: Neither cell in Area B required redredging

The majority of redredging was conducted on the basis of PCB sampling results; however, several cells were also redredged due to PAH sampling results. Verification sampling methods are discussed in Section 3.3.4; the interpretation and use of verification sampling results—both to guide redredging decisions and evaluate the overall success of the remediation—is presented in Section 6.

As stated above, redredging was required in 50% of the dredge cells. Table 3-6 lists the extent of redredging in each subarea of the site. The percentage of cells requiring two or more dredge passes ranged from a high of 77% in Area 3D to 26% in Area 1A. The two cells in Area B were remediated on the first pass and thus excluded from the redredging analysis.

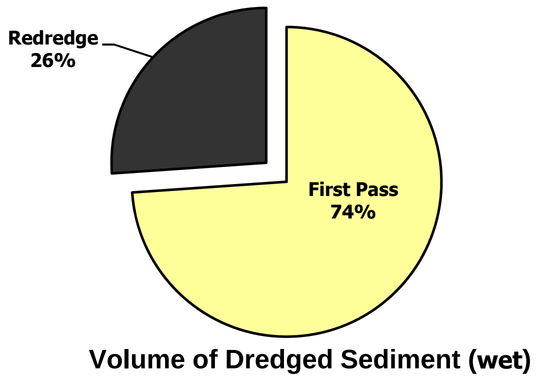
Table 3-6
Redredging Summary by Subarea

	Number of Cells in Each Area					
	1A	2C	2D	3C	3D	Total
2 dredge passes	9	10	10	5	44	78
3 dredge passes	--	5	8	7	2	22
4 dredge passes	--	7	4	3	--	14
5 dredge passes	--	3	1	3	--	7
6 dredge passes	--	2	--	--	--	2
7 dredge passes	--	3	--	2	--	5
8 dredge passes	--	1	--	2	--	3
9 dredge passes	--	--	--	2	--	2
10 dredge passes	--	1	--	--	--	1
Total per subarea	*9*	*32*	*23*	*24*	*46*	*134*

A total of 546 dredge passes were eventually conducted for the project. Subtracting out the 268 dredge passes completed for the first pass, redredging efforts resulted in 278 additional dredge passes for the 134 cells that needed redredging. Redredging removed approximately 22,390 yd^3 of sediment (wet) and 6,793 lb of PCBs, corresponding to 26% of the total volume removed and 34% of the total PCB mass removed.

A comparison of the volume and mass removed in redredging to that removed for first pass dredging is shown in Figure 3-15 (Section 3.3.3 presents the basis for the volume and mass removal estimates). The chart shows that the for an equivalent level of effort (the number of dredge passes was more or less evenly divided between dredging and redredging), nearly 3 times as much contaminated sediment was removed during the first pass dredging in comparison to redredging.

In terms of mass removal, the first pass dredging removed about twice as much PCBs as did the redredging, but redredging still made a substantial contribution to the overall mass of PCBs removed. This comparison shows that while redredging may not have yielded much in the way of sediment, the additional efforts were successful in accomplishing additional PCB mass removal.



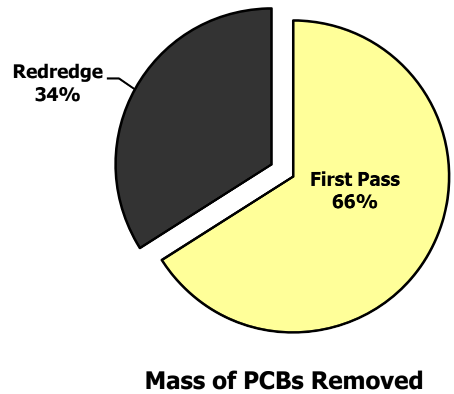


Figure 3-15
Relative Contribution of First Pass vs. Redredging for Volume and Mass

Redredging was also conducted near the end of the dredging activities using the conventional rock bucket and Cat 350. A description of these alternative dredging methods is presented below

Alternative Redredging Methods

Redredging was also conducted in 24 cells using the conventional rock bucket and hydraulic clamshell of the Cat 350 (Figure 3-16). Table 3-7 lists these cells, the type of bucket used, the date, and for which dredge pass. The decision to utilize alternative dredging methods was based on the presence of persistent contamination in these cells and the fact that previous dredging attempts had not been successful in reducing contamination levels. Such situations indicated that the limitations of the dredging technology being used for the project—the Cable Arm environmental buckets—had been reached. Use of these alternative dredging methods represented the final attempt to remediate these cells. A discussion of the effectiveness of these efforts is presented in Section 6.

The conventional rock bucket consisted of a 2.5 yd^3 clamshell bucket that could be used with the lattice boom cranes on the derrick barges. The bucket was capable of digging into the more resistant hard bottom material (glacial till and dense silty clays) and also was more effective in removing rocks and gravel. The disadvantages of the conventional bucket is that it did not have the venting system to allow water to pass through the opened bucket during descent, which minimizes downward water pressure and sediment disturbance, nor did it have the regulated closing system or overlapping side seals that minimize both the disturbance of sediment on the bottom and reduce sediment loss on closure.

The Cat 350 had a hydraulically-operated clamshell bucket with a 2.5 yd^3 capacity. The hydraulics on this bucket provided for better closure, and also allowed it to dig into stiff sediment and rocky material. Its primary disadvantage was that the operator had to be extremely careful not to overfull the bucket, as it was open at the top. If the bucket was overfilled, excess sediment fell back into the excavation during the lift cycle.

Figure 3-16
Alternative Dredging Methods for Removal of Contaminated Sediment

Table 3-7
Redredging with Alternative Dredging Methods

Cell	Date	Comments	Pass
C-24	9/24/01	Relief - Conventional Bucket	5
C-45	9/25/01	Relief - Conventional Bucket	3
C-43	9/25/01	Relief - Conventional Bucket	3
C-44	9/25/01	Relief - Conventional Bucket	5
C-64	9/26/01	Relief - Conventional Bucket	3
C-63	9/26/01	Relief - Conventional Bucket	4
C-87	9/27/01	Relief - Conventional Bucket	3
C-62	9/27/01	Relief - Conventional Bucket	4
C-76	9/27/01	Relief - Conventional Bucket	4
C-61	9/27/01	Relief - Conventional Bucket	5
C-43	10/4/01	Relief - Conventional Bucket	5
C-42	10/4/01	Relief - Conventional Bucket	6
C-41	10/4/01	Relief - Conventional Bucket	6
C-44	10/5/01	Relief - Conventional Bucket	7
C-45	10/5/01	Relief - Conventional Bucket	4
C-64	10/5/01	Relief - Conventional Bucket	4
C-78	10/6/01	Relief - Conventional Bucket	3
C-88	10/6/01	Relief - Conventional Bucket	3
C-63	10/6/01	Relief - Conventional Bucket	5
C-62	10/8/01	Comanche - Conventional Bucket	6
C-75	10/9/01	Comanche - Conventional Bucket	7

Cell	Date	Comments	Pass
C-60	10/9/01	Comanche - Conventional Bucket	7
C-61	10/9/01	Comanche - Conventional Bucket	7
C-76	10/9/01	Comanche - Conventional Bucket	6
C-69	10/10/01	Cat 350	6
D-126	10/10/01	Cat 350	5
C-83	10/10/01	IV Spot - Conventional Bucket	5
C-44	10/10/01	IV Spot - Conventional Bucket	8
C-24	10/11/01	IV Spot - Conventional Bucket	8
C-9	10/11/01	IV Spot - Conventional Bucket	4
C-71	10/11/01	Cat 350	5
D-130	10/11/01	IV Spot - Conventional Bucket	4
C-72	10/11/01	Cat 350	3
D-120	10/12/01	Cat 350	3
C-44	10/13/01	Cat 350	10
C-43	10/13/01	Cat 350	7
C-62	10/15/01	Cat 350	8
C-63	10/15/01	Cat 350	7
C-61	10/15/01	Cat 350	9
C-45	10/16/01	Cat 350	6
C-60	10/16/01	Cat 350	9

Neither the conventional or hydraulic clamshell buckets were designed for the type of environmental application needed for the St. Lawrence River project, which is why RMC selected—with EPA's concurrence—the Cable Arm bucket. The Cable Arm bucket has limitations, however, which were clearly reached in the cells where these alternative methods were used. Repeated dredging with the Cable Arm was yielding little if any sediment from these cells and verification sampling indicated persistent contamination levels well above the cleanup goals.

RMC discussed the option of using these alternative dredging methods with EPA's onsite representatives. These discussions, initially focused on a group of 9 cells in Area C that had persistent PCB contamination above 50 ppm, led to the decision to redeploy a silt curtain around the area where the conventional bucket was going to be used. The silt curtain was deployed as described in the *Work Plan for Area C Silt Curtain Redeployment and Dredging of >50 ppm Cells*. Nine cells were dredged using the Relief derrick barge with the conventional bucket between September 24 and September 27, 2001.

This initial round of alternative dredging met with mixed success, and several more dredge passes were completed using the conventional bucket. These additional passes were also completed with the temporary silt curtain. The temporary silt curtain was difficult to maintain in its proper position, a limitation that probably reduced its overall effectiveness. During the last week of dredging, the Cat 350 was placed back on a barge and used to dredge 10 cells in Area C and 2 cells in Area D that had persistent levels of PCB (and in one case, PAH) contamination. Cat 350 dredging began on October 10 and continued through October 16, 2001. These results also met with mixed success, as several of the cells dredged with the Cat 350 ended up being capped.

Estimates of the quantity of sediment removed using alternative dredging methods are shown in Table 3-8. The total includes sediment removed for navigational dredging as well as alternative dredging for removal of contaminated sediment. The values could not be separated given the placement of spoils from both types of dredging into a barge—the derrick barges often completed the first pass on a cell after a portion of it had been dredged for navigational purposes.

Table 3-8
Estimated Volume of Sediment Removed Using Alternative Dredging Methods

Bucket Type & Derrick	No. of Truckloads	Quantity of Wet Sediment (cy)
Conventional Rock Bucket		
Relief	379	3,790
Comanche	22	220
IV Spot	54	540
Hydraulic Clamshell		
Cat 350	247	2,470
Total quantities	***702 truckloads***	***7,020 cy***

Note: Quantities include sediment removed during navigational dredging

3.3.3 Dredging Performance Evaluation

The following evaluation of dredging performance focuses on attaining the target depth of cut identified in the design, discusses the estimated volumes of contaminated sediment dredged from the river, and presents the results of calculations concerning the weight of sediment (tons) and mass of PCBs (lb) removed from the river. Section 6 presents a detailed discussion of the results of the remediation based on an evaluation of meeting the sediment cleanup goals and satisfying the requirements of the ROD, ROD Amendment, and Final Design.

3.3.3.1 Final Depth of Cut

The average depth of cut for each dredge cell was determined using the WINOPS data. A detailed description of the data reduction and processing and potential errors in determining depth of cut is presented in Appendix B; a brief overview of the procedure is presented below.

For the first pass over a cell, the depth of cut (or cut elevation) was determined from WINOPS data by subtracting the pressure transducer reading value, representing the elevation of the bucket lip within the sediment, from the tide elevation. As the Cable Arm bucket makes a level cut, the elevation of the bucket lip corresponds to the elevation of the new cut surface. The pre-cut river bottom elevation was calculated by adding the sounder data (which identified the depth of penetration into the sediment) to the cut elevation. First pass depth of cut data (average depth of cut, across the cell) are presented in Table 3-3 of Appendix B.

For the redredging passes (all subsequent passes over a cell), the cut elevation was determined by subtracting the pressure transducer reading from the tide elevation. The pre-existing bottom elevation was not determined for the redredge passes as the sounder data was not as reliable as that of the First Pass (see data reduction discussion in Appendix B). The redredge depth of cut was calculated by subtracting the average of the pressure transducer readings for the final dredge pass over a cell from the first pass pressure transducer readings. Depth of cut data for the redredge passes are also presented in Table 3-3 of Appendix B.

The presence of physical obstructions or other unsuitable conditions for dredging complicated the resolution of the depth of cut data. By definition, it was not possible to close the bucket in an area with an obstruction. No valid records were created in WINOPS for sounder and transducer readings when the bucket could not close or the water was too shallow to obtain valid readings. By definition, however, the obstruction is not amenable to dredging, and depth of cut data from locations with obstructions should not be included in the calculation of average depth of cut across the cell.

Figure 3-17 shows the distribution of obstructions and other problems identified and logged with the WINOPS data during dredging activities. Three types of obstruction or problem area are shown: rocks, hard bottom, and shallow water. Rocks and hard bottom were encountered in many if not most of the dredge cells across the site. Hard bottom conditions were most commonly identified on redredging activities, after the first or earlier passes had removed all of the soft sediment.

Table 3-9 presents a summary of the comparison between the average, total depth of cut attained in the cells (including both first cut and redredge passes) with the target depth of dredging for that cell (discussed previously). The table also includes data for the 9 hot spots that had >500 ppm PCBs. For each area, the number of cells is presented, as is the number of cells in each area for which the total depth of cut was equal to or greater than the target depth, and the number of cells in which the total depth of cut was less than the target depth.

Table 3-9
Depth of Cut Summary for Dredge Cells and Hot Spots

	No. of Cells or Hotspots				
	Total	≥ Target Depth[a]	< Target Depth[a]	Locations where Final Cut < Target Depth	Average Difference[b]
Area A	35	23	12	A-1, A-2, A-9, A-12, A-16, A-17, A-19, A-20, A-21, A-27, A-28, A-30,	0.06 ft
Area B	2	2	0	--	--
Area C[c]	91	81	10	C-17, C-31, C-33, C-48, C-55, C-58, C-73, C-89, C-90, and C-91	0.55 ft
Area D	140	130	10	D-18, D-20, D-43, D-50, D-73, D-74, D-92, D-93, D-132, D-136	0.14 ft
Hot Spots	9	8	1	HS-9	0.04 ft
Total	*277*	*244*	*33*	--	*Avg. = 0.23 ft*

Note: Appendix B presents a discussion of potential errors and limitations in quantifying the depth of cut during dredging activities provided in Appendix B
a. Comparison with target depth based on combined depth of dredging from all passes.
b. Average difference for all cells where Final Cut < Target Depth
c. These 10 cells received only one dredge pass, and either the depth of cut was less than 24 inches after the first pass or no depth of cut data were generated (e.g., due to equipment problems), and, all 10 cells had >1 ppm PCBs in the final verification sample.

As shown in Table 3-9, about 88% of the dredge cells (including hot spots) attained the target depth of cut identified in the design. In most instances, for cells that did not meet the target depth, the total cut was within a few hundredths or tenths of a foot. The average difference between the target depth and the average depth of cut across the 33 cells that did not meet the target depth was only 0.23 ft, about 3 in.

3.3.3.2 Volume of Contaminated Sediment

Estimates of the volume of contaminated sediment removed by dredging were determined using three different approaches, yielding three different volumes due to the methods used to develop the estimate. Each of these is discussed below. Reconciliation of the various volume estimates and the relationship between volume and mass is discussed in Section 3.3.3.5.

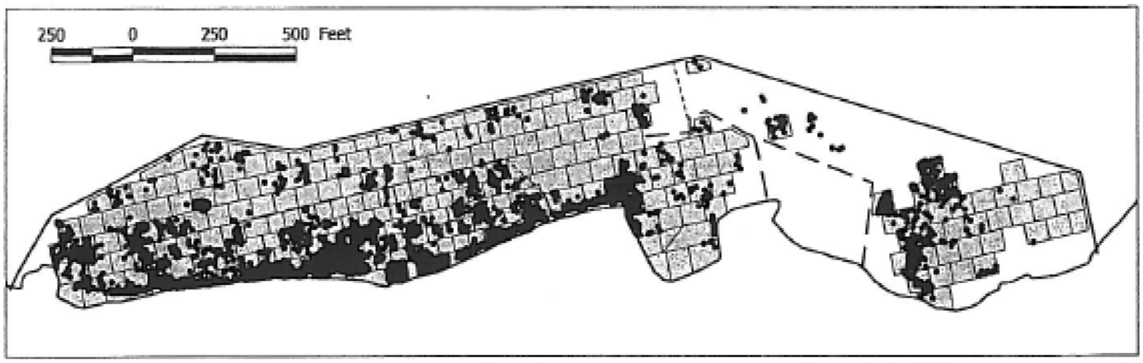
Estimated Volume Based on Depth of Cut (In-place Volume)

An estimate of volume removed was calculated from the depth of cut data, presented above, within a known area (i.e., cell boundaries) (See Plate 1-1). The depth of cut data was averaged for each cell's First Pass and the final Re-Dredge to yield an average cut depth in feet. This cut value was multiplied by the area in square feet of the cell footprint and divided by 27 to yield a cubic-yards-removed estimate. Appendix B presents the calculated volume removed for each cell. The results of volume calculations using this methodology yielded a total volume removed of 54,363 yd^3, which represents the in-place volume (i.e., does not consider the natural bulking due to excavation or the water added during dredging).

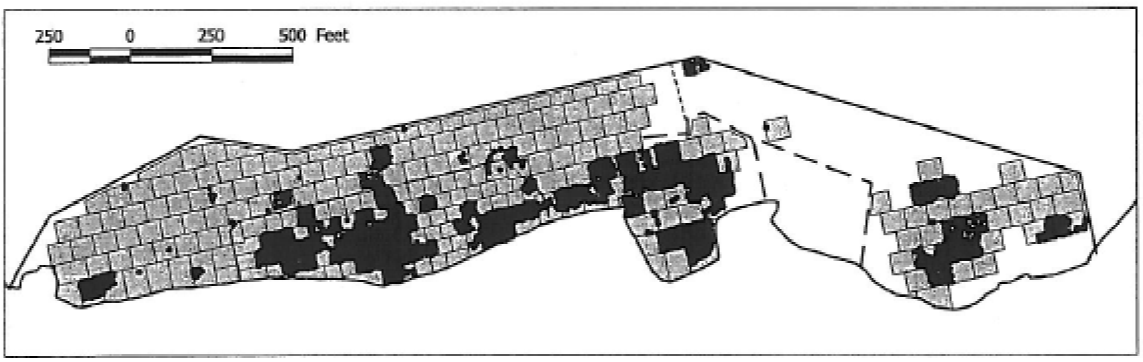
The in-place volume is based on the depth of cut calculations, which in turn are based on WINOPS depth data. For this reason, the in-place estimate does not include sediment removed during dredging with alternative methods nor sediment excavated from the shoreline. These quantities are accounted for in the volume estimate derived from truck counts, which is explained below.

Estimated Volume Based on Barge Quantities

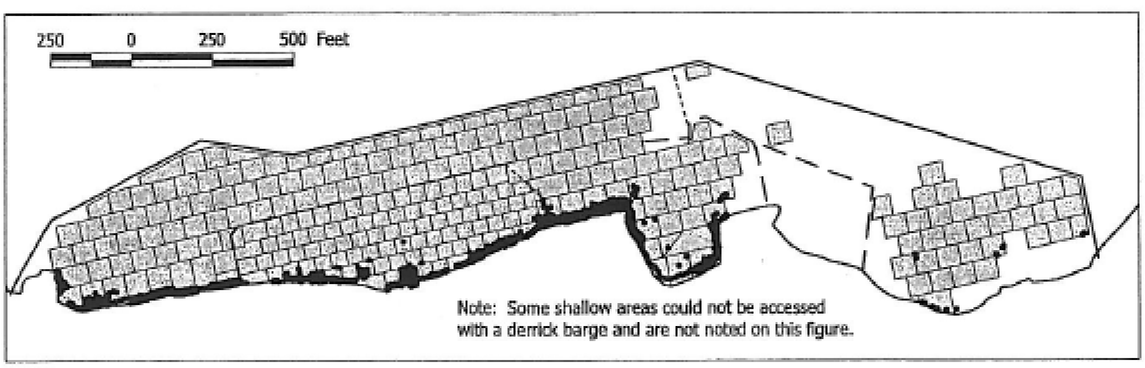
Daily estimates of the quantity of dredge spoil placed in each material barge were prepared for the morning planning meetings. These estimates were based on two different, highly subjective estimating methods, one involving the loaded draft (displacement) of the vessel, and the second based on quantity estimates recorded on the bucket logs (described above). Barge quantity estimates were based on the wet sediment—that is, there was no discounting of volume based on the water content. A total of 417 barge-loads of wet sediment were eventually filled and brought to the East Dock for unloading. The estimated total quantity of material dredged, based on the quantities of wet sediment in these 417 barge-loads, was 67,550 yd^3. This estimate is not considered further in this evaluation as it could not be reconciled with the known quantities shipped offsite, landfilled, etc.



Plot A
Obtructions Attributed to Rocks



Plot B
Obtructions Attributed to Hard Bottom



Plot C
Obtructions Attributed to Shallow Water

Figure 3-17
First Pass Obstructions

Estimated Volume Based on Truck Counts

The third estimation method to determine the volume of sediment removed from the riverbed was based on the detailed truck logs that documented every truckload of sediment obtained from either the barge unloading operations at the East Dock or shoreline excavation activities. Combined with data concerning the date and location where the material in a given barge was dredged, the volume estimates based on truck count were considered to represent the most accurate means of accounting for the quantities of wet sediment removed from the river.

The truck counts account for every load of sediment sent directly to the landfill, and every load of sediment placed in stockpiles created in the sediment pens or drying beds. It was also possible to conduct a more detailed analysis of the volumetric data based on truck counts, by linking the trucks to the dredging history (via the material barges) as well as the stockpile characterization results, landfill quantities, and other post-unloading sediment handling activities.

The count was compiled by totaling the loads from the driver's daily logs. Each driver's log contained a record of each load they carried, including the time the truck was loaded, the barge that the load originated from, and the load's destination. The number of truckloads was then multiplied by an average volume of sediment per truckload. While the volume of sediment varied for each load, the excavator operators on the East Dock typically filled each truck with approximately 10 cy.

Table 3-10 provides a summary of the number of truckloads and the resulting volume of sediment based on the assumption of 10 yd^3 per truckload. As shown in the table, there were 8,566 truckloads of sediment hauled from either the East Dock or during shoreline-based sediment removal activities (conducted primarily in Area C), resulting in a total volume of 85,660 yd^3 of wet sediment. The sensitivity of this estimate on the assumed volume of material per truckload is readily apparent.

Table 3-10
Estimated Volume of Sediment Removed Based on Truck Logs

Area	Number of Truck Loads	Volume (cy))
Landfill (<50 ppm PCBs)	6,025	60,250
Sediment Storage Area Stockpiles		
<50 ppm PCBs (landfill)	781	7,810
≥50 ppm PCBs (offsite)	1,070	10,700
>500 PCBs (offsite)	362	3,620
subtotal	*2,213*	*22,130*
River Drying Beds Stockpiles		
<50 ppm PCBs (landfill)	94	937
≥50 ppm PCBs (offsite)	141	1,406
>500 PCBs (offsite)	94	937
subtotal	*328*	*3,280*
Total	***8,566***	***85,660***

Note: the categories under sediment storage area and river drying beds refer to the final disposition of the sediment based on characterization of various stockpiles having the total volume indicated.

Sediment brought to the Sediment Storage Area and the River Drying Beds was placed in holding pens where a composite sample was collected. Based on the results of the sample, it was then determined whether the sediment would be shipped to the on-site landfill (if the material had <50 ppm PCBs), shipped to an off-site disposal facility (if the material had ≥50 ppm PCBs), or set aside for treatment pending shipment to an offsite disposal facility (>500 ppm PCBs).

In Table 3-10, the breakdown of the number of loads from the Sediment Storage Area and the River Drying Beds to the on-site landfill or the off-site facilities indicates the number of truckloads of wet sediment rather than the number of truckloads of stabilized material that was shipped out of these locations. In other words, the truck counts reflect the number of truckloads that went into each of the stockpiles, and how the material in the stockpile was eventually dispositioned determined how the loads were assigned to one of the categories (landfill, ≥50 ppm, etc.)

As a check of the sediment volumes, the estimated volume of wet sediment brought to the on-site landfill was compared to the as-built volume of sediment placed in the landfill. The as-built volume in the landfill was calculated by comparing the topographic surveys performed in December 2000 (prior to the placement of any river sediment) with the survey performed in November 2001 (after placement of all river material).

Based on the difference between the two surveys, and accounting for the in-place density of the landfilled sediment, 50,300 yd^3 of stabilized material was placed and compacted in the landfill. This number contrasts with the estimated volume of 68,997 yd^3 of wet sediment that was either brought directly to the landfill or was first brought to either the Sediment Storage Area or River Drying Beds prior to hauling to the landfill. Based on these volumes (68,997 vs. 50,300), the volume of landfilled sediment was reduced 37% through the stabilization and compaction process. This analysis assumes that the landfilled sediments were stabilized with ~15% Portland cement (by weight).

Volume per Dredge Pass

Combining the truck log data with information in the marine technician journals and bucket logs, it was possible to define the area and volume removed for each dredge pass. The journals and bucket logs provided information as to which cells were being dredged at a given time and which material barge the sediment was being loaded into. The journals provided the date/time when a derrick began loading a material barge and when the barge was filled and sent to the East Dock to be unloaded. The bucket logs were used to identify the cells that were being dredged from which the sediment was placed into the material barge.

By separating out each unique barge load, it was possible to associate not only the cells from which the sediment in each barge load was derived, but also the dredge pass number and the PCB concentration after the previous dredge of each cell in the load. The number of truckloads and the destination of the material were also associated with each barge load. Based on this information it was possible to estimate the volume of sediment and mass of PCBs removed for each dredge pass.

The volume for each pass was determined by assigning the lowest dredge pass of all the cells from which sediment was placed into a material barge. For example, if a given barge-load of sediment had material from the 3rd pass on one cell and the 2nd pass on another, the barge volume was considered to represent 2nd pass dredging. This assumption was based on field observations and data indicating that the quantity of sediment excavated from a given cell typically declined with each successive dredge pass. When different dredge passes were represented within a given barge, it was assumed that the majority of the sediment was generated from the lowest-numbered dredge pass.

A limitation of this approach is that it was not possible to define the volumes for the final set of dredge passes (9th or 10th) as the sediment from these passes was combined in a material barge that contained sediment from lower-numbered dredge passes from other cells. This limitation also prevented the calculation of PCB mass removed for the final set of dredge passes.

Table 3-11 lists the volume removed per dredge pass and also the total surface area dredged for each pass. For example, there were 78 cells that had two dredge passes. The combined surface area covered by going over these 78 cells on two separate dredge passes was 10.74 acres. The volumes per dredge pass were briefly discussed above in the discussion of the quantities dredged from the first pass and redredging activities.

Table 3-11
Quantity of Sediment Removed per Dredge Pass

	Surface Area Dredged		Volume Removed		Quantity (cy) per acre
Pass	acres	% of total	cy	% of total	
1	21.83	53.2	63,270	73.9	2,898
2	10.74	26.2	17,140	20.0	1,596
3	3.73	9.1	2,790	3.3	748
4	2.00	4.9	670	0.8	335
5	1.06	2.6	580	0.7	547
6	0.65	1.6	800	0.9	1,231
7	0.55	1.33	300	0.4	545
8	0.30	0.73	110	0.1	367
9	0.15	0.36	--	--	--
10	0.05	0.12	--	--	--
Total	***41.05***	***100***	***85,660***	***100***	--

Table 3-11 includes the quantity of wet sediment generated per acre of surface area dredged, which normalized the sediment volume data, providing an indication of dredging performance (in terms of sediment yield) with increasing level of effort (dredge passes). These data are plotted in Figure 3-18.

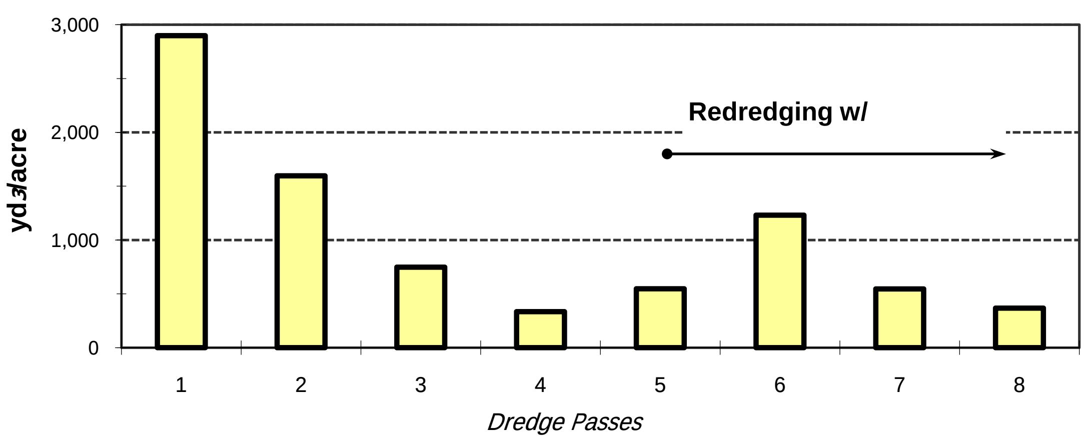


Figure 3-18
Wet Sediment Yield per Acre, Total Area Dredged per Pass

The chart shows that the sediment yield declined significantly after the first pass, which apparently removed most of the available soft sediment from the dredge cells. By the 4th pass, the yield had declined 88% (from 2,898 to 335 yd^3/acre). Only when the alternative dredging methods identified above were applied (which on average were used beginning with the 5th pass) did the sediment yields begin to increase. Even with these alternative methods, however yield eventually declined back down to about the same level obtained on the 4th pass (i.e., about 13% of that obtained from the 1st pass). Continued dredging—in terms of volume removed—was unlikely to generate much more in the way of contaminated sediment, regardless of the methodology employed.

These data indicate that dredging removed about as much sediment as could be removed—essentially all the sediment that was amenable to dredging, given the limitations of the dredging technology and site-specific bottom conditions at the site.

3.3.3.3 Weight of Sediment Removed

The weight of the sediment removed from the river was calculated by multiplying the sediment volume by the density of the sediment. To determine the sediment density, a series of truckloads of wet sediment was weighed on the on-site scales, and the weight of the sediment was divided by the assumed volume of 10 yd^3 per truckload (Table 3-12).

Table 3-12
Calculation of Sediment Density

Location	No. Truckloads	Volume of Wet Sediment (cy)	Tons Per Truck	Weight of Wet Sediment (tons)
Pen 10	24	240	12	287
Pen 12	26.5	265	9.3	245
Pen 11	24.5	245	10.9	266
Bed 2	18.5	185	11.3	209
Pen 16	27.5	275	10.9	299
Pen 17	26.5	265	10	264
Pen 9	26	260	10.6	275
Pen 13	27.5	275	12.1	333
Pen 12	26	260	10.3	268
Bed 1	26	260	10	259
--	*avg. = 25*	*Σ = 2,630*	*avg. = 10.7*	*Σ = 2,705*

Note: Location refers to stockpile location created by truckloads indicated

The following equation shows how truck weight data were used to determine a unit weight (pounds per cubic foot or pcf) for the wet sediment:

$$\text{Sediment Density} = \frac{\text{Weight}}{\text{Volume}} = \frac{2705 \text{ tons}}{2630 \text{ yd}^3} = 1.03 \frac{\text{tons}}{\text{yd}^3} = 76 \frac{\text{lbs}}{\text{ft}^3}$$

The volume of sediment was then multiplied by the sediment density (76 pcf) to calculate the weight of the wet sediment removed from the river. The weight calculation is summarized in Table 3-13.

Table 3-13
Calculation of the Weight of Sediment Removed

Area	Volume (cy)	Weight of Wet Sediment (tons)
Landfill (<50 ppm PCBs)	60,250	61,817
Sediment Storage Area Stockpiles		
<50 ppm PCBs (landfill)	7,810	8,013
≥50 ppm PCBs (offsite)	10,700	10,978
>500 PCBs (offsite)	3,620	3,714
subtotal	*22,130*	*22,705*
River Drying Beds Stockpiles		
on-site landfill	937	962
≥50 ppm PCBs (offsite)	1,406	1,442
>500 PCBs (offsite)	937	962
subtotal	*3,280*	*3,365*
Total Quantity & Weight	***85,660***	***87,887***

Note: the categories under sediment storage area and river drying beds refer to the final disposition of the sediment based on characterization of various stockpiles having the total volume indicated.

As an additional check of the volumes and weights of the sediment removed from the river based on truck counts, the estimated weight of the sediment shipped offsite was compared with the actual weight of the material, based on truck weight tickets. Prior to comparing the weights, the wet sediment weight was converted to an estimated weight of stabilized sediment. The total weight of Portland cement purchased throughout the project for stabilizing the sediment was 13,143.59 tons or 15.3% of the total weight of the wet sediment removed from the river.

Table 3-14 lists the estimated weight of the wet sediment, the estimated weight of the stabilized material (based on a 15.3% increase due to the weight of the cement), and the actual weight of material shipped off-site.

Table 3-14
Comparison of Estimated vs. Actual Off-site Shipment Weights

	≥50 and <500 ppm	>500 ppm	Total
Estimated Weight of Wet Sediment Shipped Off-site [a]	12,420 tons	4,676 tons	17,096 tons
Estimated Weight of Stabilized Material Shipped Off-Site [b]	14,326 tons	5,393 tons	19,719 tons
Actual Weight of Stabilized Material Shipped Off-Site [c]	16,447 tons	5,909 tons	22,356 tons
Percent Difference	*-12.9 %*	*-8.7 %*	*-11.8 %*

a – Weight of sediment from Table 3-_ (Sediment Storage Area plus River Drying Beds)
b – Stabilized weight = wet weight + (wet weight × 15%)
c – Based on truck weight tickets

The estimated weights of material shipped offsite are approximately 12% lower than the actual, measured weights. This indicates the truck-based volume estimate of the wet sediment removed from the river is conservative, but is close enough to the true value to indicate that the truck-based estimates are reasonable.

3.3.3.4 Mass of PCBs Removed From the River

Estimates of the mass of PCBs removed in the contaminated sediment were calculated using two different methods, each based on the manner in which the sediment was handled after it was unloaded at the East Dock. Information from the marine technician logs and bucket logs allowed the mass estimates to be tied to specific cells and dredge passes as explained above in the discussion of truck-based volume estimates.

Sediment removed from the river was handled differently depending upon whether it came from cells with a known, in-place concentration of <50 ppm PCBs, or cells with a known or suspected, in-place concentration of ≥50 ppm PCBs. Sediment removed from cells with sample results of PCB concentrations less than 50 ppm was hauled directly to the on-site landfill, while sediment removed from cells with known or suspected PCB concentrations equal to or greater than 50 ppm was brought to either the Sediment Storage Area or the River Drying Beds where a composite sample was taken from the pen or bed.

The composite sediment sample results were used to calculate the weight of PCBs (mass) in each of the stockpiles (composite sampling procedures and sampling results are discussed in Section 3.5.4). The weight of PCBs in sediment brought directly to the onsite landfill was calculated using verification sample results (verification sampling procedures are discussed in Section 3.3.4); verification sampling results are presented and evaluated in Section 6.1). Each of these approaches to estimating the mass of PCBs removed is examined below.

Sediment from Cells with ≥50 ppm PCB

Sediment from cells with sample results indicating the sediment had PCB concentrations equal to or greater than 50 ppm was placed in specially designated barges and trucks and transported to either the Sediment Storage Area or River Drying Beds. The sediment was dumped into a pen (or bed) until the pen (or bed) was full. After the pen or bed was filled with sediment, a composite sample was collected to determine whether the material could be placed in the on-site landfill (if < 50 ppm PCB) or whether it had to be shipped to an off-site disposal facility.

The weight calculation of PCBs in the sediment brought to the Sediment Storage Area and River Drying Beds was based on the volume (truckload counts) associated with a specific stockpile created in a specified pen and the PCB concentration in the composite sample collected from that volume of stockpiled sediment. The weight of PCB removed was calculated with the following equation:

$$\text{PCB, lbs,} = \text{PCB Conc., ppm} \times \text{Volume of Sediment, yd}^3 \times \text{Sediment Density, } \frac{\text{lbs}}{\text{yd}^3} \times 10^{-6}$$

The PCB concentration was taken from the composite sample result, and the volume of sediment was the estimated volume of wet sediment in the stockpile. The estimated density of the river sediment is 76 lb/ft^3 or 2052 lb/yd^3. The PCB weight was calculated on a stockpile-by-stockpile and pen-by-pen basis. Table 3-15 summarizes the weight of PCBs removed from the river.

Table 3-15
Calculation of the PCB Mass Removed

Area	Wet Volume (cy)	Weight of PCBs (lbs)	Avg. Conc. (ppm PCBs)
Landfill (<50 ppm PCBs)	60,250	1,251	10
Sediment Storage Area Stockpiles			
<50 ppm PCBs (landfill)	7,810	344	21
≥50 ppm PCBs (offsite)	10,700	2,824	129
>500 PCBs (offsite)	3,620	13,756	1,852
subtotal	*22,130*	*16,923*	*373*
River Drying Beds Stockpiles			
<50 ppm PCBs (landfill)	937	53	27
≥50 ppm PCBs (offsite)	1,406	572	198
>500 PCBs (offsite)	937	1,399	727
subtotal	*3,280*	*2,023*	*301*
Overall	***85,660***	***20,197***	***193***

Note: the categories under sediment storage area and river drying beds refer to the final disposition of the sediment based on characterization of various stockpiles having the total volume indicated.

The total weight of PCB in the material brought to the Sediment Storage Area was 16,923 lb, and the total volume was 22,130 yd^3. The total PCB weight at the River Drying Pens was 2,023 lb, and the total volume was 3,280 yd^3. The average PCB concentration was calculated by dividing the weight of the PCB removed by the total weight of the sediment. The average PCB concentration in the sediment brought to the sediment pens was 380 ppm; the average was 282 ppm at the drying beds.

PCB Mass from Cells with < 50 ppm PCB

The weight calculation of PCBs removed from cells with less than 50 ppm PCBs—that is, the material hauled directly to the onsite landfill without stockpiling and characterization sampling—was not as direct as the method used for cells with concentrations ≥50 ppm PCBs since no samples were collected from the material after it was removed from the river. To calculate the weight of PCB removed in cells with less than 50 ppm, the volume of material removed from each barge was multiplied by the average of the PCB concentrations of each cell that was dredged to fill the barge. If material from three different cells was placed in a certain barge, the PCB concentration for all the material in that barge was calculated by averaging the most recent sample results for each of those three cells. A PCB weight was then calculated for each barge load of sediment that was unloaded at the East Dock. These data were also summarized in Table 3-15.

The mass of PCBs removed from cells with less than 50 ppm was 1,251 lb. Given the weight of wet sediment placed in the landfill (61, 817 tons, based on 60, 250 cy), the average concentration of PCBs in the material placed in the landfill was 10 ppm. An additional 397 yd^3 of set sediment was sent to the landfill after stockpile characterization samples indicated <50 ppm PCBs; the average PCB concentration in this material was 21 – 27 ppm.

The total weight of PCB removed from the river was 20,197 lb, which corresponds to an average PCB concentration in the 85,660 yd^3 of wet sediment dredged from the river of 193 ppm. Figure 3-19 presents a breakdown of the final disposition of the PCB mass removed from the river.

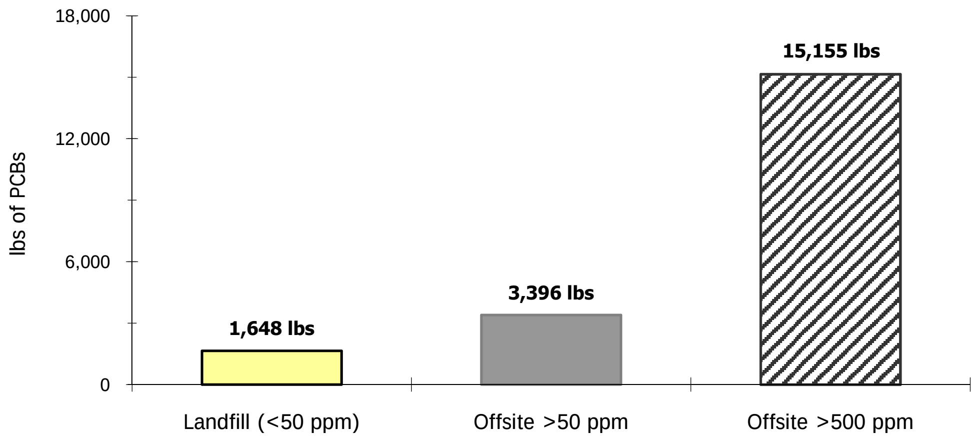


Figure 3-19
Disposition of PCB Mass Removed from St. Lawrence River

Approximately 92% of the PCB mass removed from the river was sent to the TSCA-permitted Model City facility for disposal. The remaining 8% of the mass, about 1,650 lb, was disposed of in the onsite landfill in a manner consistent with NYSDEC requirements governing landfill operations and closure.

Mass Removal per Dredge Pass

The same approach detailed above for calculating sediment volumes for each dredge pass was also used to evaluate PCB mass removal for each dredge pass. Table 3-16 lists the mass of PCBs removed per dredge pass and the total surface area dredged for each pass (defined earlier). Normalized PCB mass removal data, based on the quantity removed per acre, are also shown. It was not possible to determine the mass of PCBs removed after the 7^{th} dredge pass due to the mixing of sediments in the material barges as described in the discussion of sediment volumes per dredge pass.

Table 3-16
Mass of PCBs Removed per Dredge Pass

	Surface Area Dredged		Mass Removed		Quantity (lb) per acre
Pass	acres	% of total	lbs	% of total	
1	21.83	53.2	13,322	66	610
2	10.74	26.2	4,728	23.4	440
3	3.73	9.1	471	2.3	126
4	2.00	4.9	422	2.1	216
5	1.06	2.6	1,069	5.3	1,009
6	0.65	1.6	68	0.3	136
7	0.55	1.33	88	0.4	160
8	0.30	0.73	30	0.15	100
9	0.15	0.36	--	--	--
10	0.05	0.12	--	--	--
Total	***41.05***	***100***	***20,197***	***100***	--

Figure 3-20 presents a plot of normalized PCB removal data (lbs of PCBs per acre dredged). These data show that PCB mass removal declined significantly after the 2nd pass. By the 3rd dredge pass, the mass removal had declined by 80% from the initial dredge pass (from 601 to 126 lb of PCBs per acre of dredging). Increases in PCB mass removal occurred beginning with the 4th pass, and included a significant spike in mass for the 5th pass, higher even than that associated with the initial dredge pass.

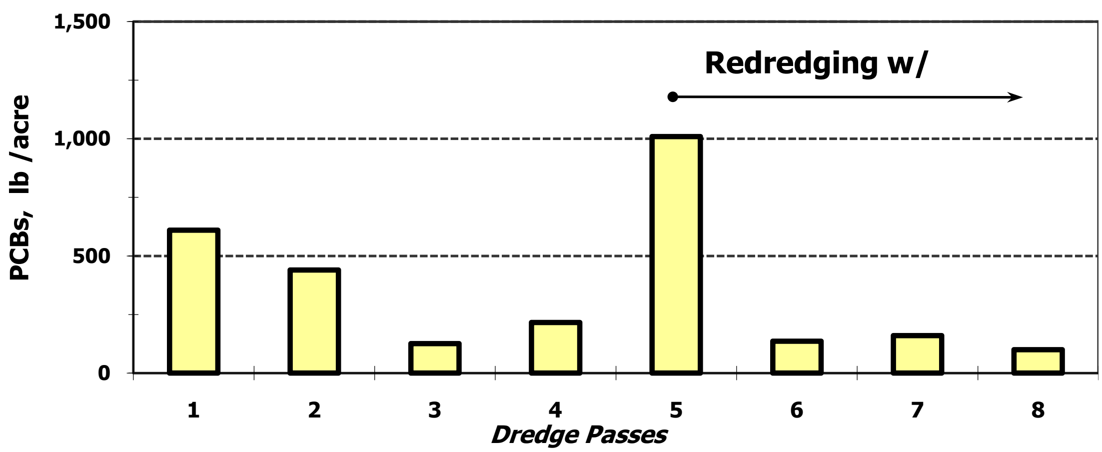


Figure 3-20
PCB Mass Removed per Acre, per Dredge Pass

The PCB mass removal history reflects the fact that the majority of the redredging efforts after the 3rd or 4th pass were focused on cells associated with the former 001 outfall (and HS-4). Sediment verification and stockpile characterization samples from a number of the cells in this area were associated with relatively high levels of PCB contamination, in some cases exceeding 500 ppm. The spike in PCB mass removal that occurred on the 5th dredge pass was attributed to stockpile sampling results, which included several with greater than 1,000 ppm PCBs.

It is also likely that the alternative dredging methods employed, beginning on average with the 5th pass, were responsible for generating a significant increase in PCB mass removal. As explained above, these methods were used primarily in cells with persistent contamination levels that yielded little if any sediment when redredging was conducted using the Cable Arm environmental buckets. Even with these alternative methods, however, the quantities of PCBs removed per area dredged declined after the 5th pass. This pattern is consistent with that observed with the sediment yield described above. Continued dredging was unlikely to generate much more in the way of contaminant mass removal, regardless of the methodology employed.

3.3.3.5 Reconciliation of Estimated Volumes and Implications for Mass Removal

As shown above, three separate estimates of the volume of dredged sediment can be obtained based on the method of estimation. Table 3-17 summarizes these volumes and also provides a breakdown of the relative contribution of the three categories of contaminated sediment in both the pre- and post-dredging estimates (truck count only for post-dredge).

Table 3-17
Comparison of Pre-and Post-Dredging Volume Estimates

		PCB Concentration, ppm			
		<50	**≥50 & <500**	**≥500**	**Total**
Pre-Dredging Estimate	**In-place volume (*neat*)**	35,000	18,500	3,100	56,600
	In-place volume w/ redredge	47,985	25,365	4,250	77,600
		61.8%	*32.7%*	*5.5%*	*100%*
Post-Dredging Estimate	**Truck counts (wet)**	68,997	12,106	4,557	85,660
		80.5%	*14.1%*	*5.3%*	*100%*
	Barge quantity in daily reports (wet)				67,550
	In-place estimate (*neat*)				56,259

For the estimates of wet sediment, the volume estimate based on truck counts (85,660 yd^3) was determined to represent the better estimate due to closer agreement with the actual quantities of material shipped to the offsite disposal facilities. The contrast between the post-dredging in-place estimate, 56,259 yd^3, and the post-dredging truck count estimate, 85,660 yd^3, was attributed to the natural bulking of excavated materials and the introduction of water into the sediment during the dredging process. The dredged sediment placed in the material barges had an extremely high water content, and this is reflected in the estimated density of the material (76 pcf), in the increased volume of dredged vs. neat sediment removed, and in the physical appearance of the material as it was being unloaded and handled prior to stabilization.

The wet volume forms the basis for the PCB mass removal calculations, as the majority of the calculated PCB mass was derived from the characterization samples collected from the stockpiles of wet sediment. All of these stockpiles were sampled as quickly as possible, for logistical reasons, and all had nearly the same water content and consistency as when the material was unloaded at the East Dock. Because the resulting PCB concentration reflected both the water content and density of the wet sediment stockpile, the calculations of PCB mass also had to be based on the volumes of wet sediment that went into creating the stockpiles.

Likewise, the analysis of PCB mass in the sediment dredged from the <50 ppm cells was based on the PCB concentration in the wet sediment collected for the verification samples. This sediment was more often than not identical to the wet sediment being placed in the barges, due either to fact that the split spoon yielded soft sediment with a high water content or the fact that the field sampling procedure called for the addition of all water from the split spoon sampler into the mixing bowl for homogenization of the sample. Either way, the resulting verification sample reflected a high water content and therefore the mass calculation for these cells was also based on the estimated volumes of wet sediment.

The final consideration is how the in place estimate of sediment removed from the river (56,259 yd^3) compares to what was predicted in the design. Table 3-_ lists the pre-dredging volume estimates, and includes both the neat estimate based on the target depth of dredging in each cell (including an overcut of 3 in.), 56,600 yc^3, and a higher volume based on the assumption that redredging would generate approximately 37% more sediment than the neat estimate, or 77,600 yd^3.

As shown in Figure 3-15 (presented earlier), the actual quantity of sediment generated through redredging activities was approximately 26% of the total. This is about one-third less than what was predicted from redredging (37%) but is not a large enough deviation to explain the difference. A number of reasons can be cited as to why the predicted vs. actual volumes differ. These include a much greater occurrence of obstructions, hard bottom, and areas not amenable to dredging, all resulting in less soft sediment than expected. In addition, the in-place estimates of sediment volume removed through dredging do not include the sediment excavated using conventional methods or from the shoreline.

3.3.4 Sediment Verification Sampling

Verification sample locations are shown on Figure 3-21. Verification sampling results are discussed in detail in Section 6.1.

Verification sampling locations in Areas A and D reflected a triangular grid spacing of 70 ft; locations in Area C were based on a triangular grid spacing of 50 ft. The configuration of these sampling grids was developed on the basis of earlier statistical studies and input from EPA. The triangular grid was used to define contaminant baseline conditions in Areas A, B, and D as documented in *Final Report – Sampling and Analysis for the River Remediation Project* (Bechtel 1996).

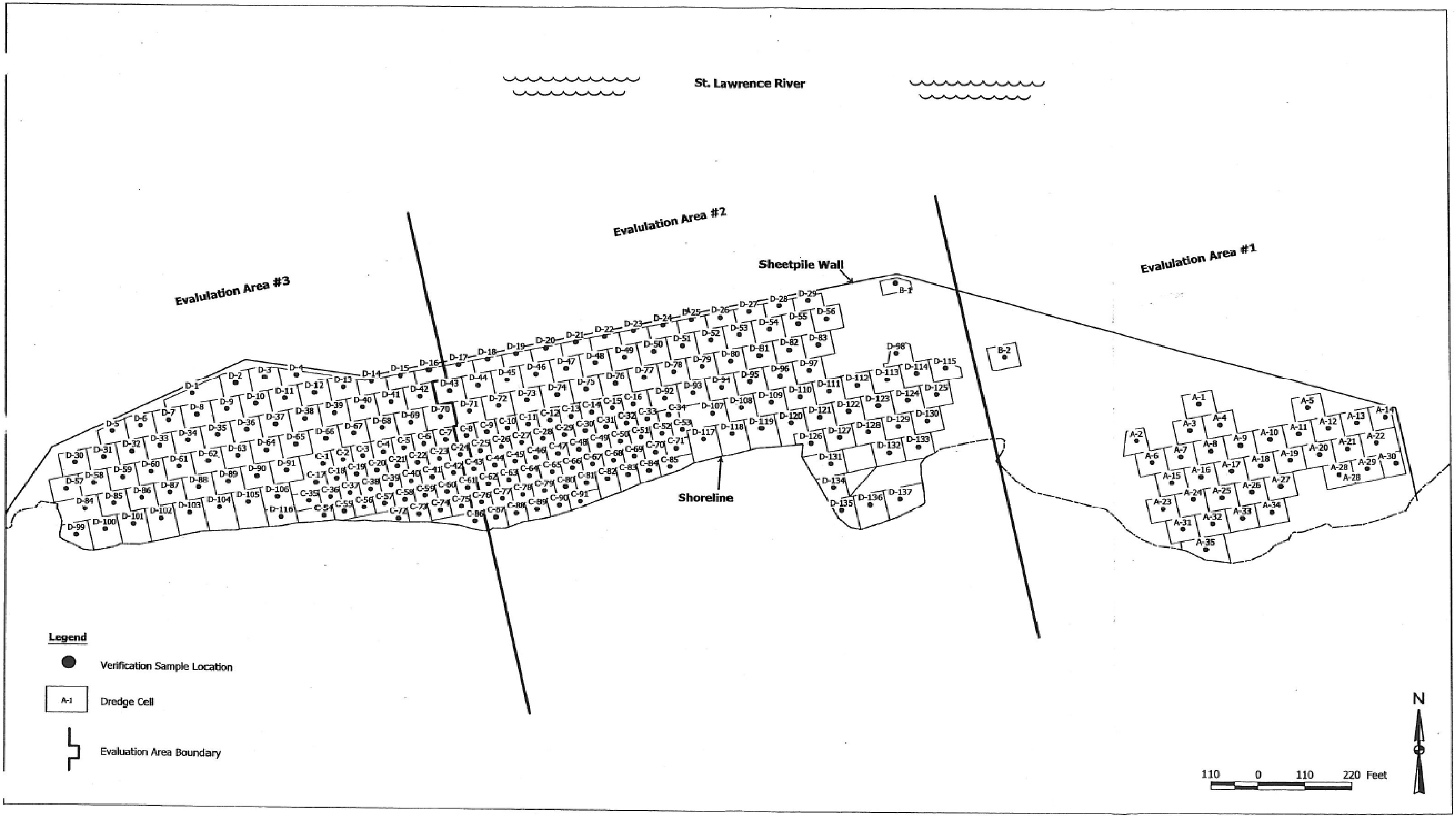


Figure 3-21
Verification Sample Locations

Verification samples were also collected from two dredge cells in Area B as well as from the 17 "no-dredge" cells in Area D. The purpose of sampling these "no dredge" cells was to determine whether dredging activities in nearby cells resulted in the contamination of these previously clean areas.

Additional sediment sampling was conducted in selected locations due to dredge access limitations, the presence of dredging obstructions, or the need to determine whether dredging or sediment transport had impacted previously clean areas. Areas where this additional sediment sampling was conducted include the following:

- Along the barge transit corridor in Area B
- Inside the portion of Area B isolated by the silt curtain (the "Area B clean cove")
- Near the shoreline in selected Area 3D cells that could not be dredged due to shallow water
- Shallow water portions of selected cells in Area 1A
- Biased sampling around obstruction in selected cells

Results from these supplemental sampling activities are presented in Section 6.

Verification samples were initially collected using a Ponar dredge sampler operated from the ATL sampling barge. When it became apparent that the Ponar would not be able to generate samples representative of the 0-8 in. sediment interval, the sampling technique was changed to the split-spoon method (Figure 3-22). Split-spoon samples were also collected from the ATL sampling barge. Both the Ponar and split-spoon samplers were identified as potential sampling methods in the EPA-approved *Environmental Management Plan* (EMP), which was part of the *Remedial Action Work Plan* (Bechtel 2001). Descriptions of the verification samples are presented in Appendix H.

The sampling locations were determined using GPS instrumentation. Sample collection procedures were conducted in accordance with the methodology detailed in the *Procedure for Surface and Subsurface Sediment Sampling, REP-002*. The only variance from this procedure was a decision to add the water within the split-spoon to the bowl used to homogenize the sediment prior to filling the sample jars. The water was added at the request of the onsite EPA representative to minimize the loss of the uppermost layer of fine sediment that often had a high water content.

The verification samples were analyzed using a field screening immunoassay method, in accordance with Method 4020 in EPA SW-846*, Test Methods for Evaluating Solid Waste, Rev. 0, 1996*. The immunoassay procedure was conducted in the field, in an ATL trailer, using the EnviroGard^{TM} PCB Soil Test Kit. Evaluation of the immunoassay results drove decisions regarding follow-on dredging and/or additional, laboratory analyses for the samples. The major components of the process are summarized below:

- When the immunoassay showed less than 1 ppm PCBs, the sample was considered to be a final verification sample. A large number of the samples (>25%) with IAA results less than 1 ppm were sent to the laboratory for analysis for verification of the field screening tests. The EMP stated that a minimum of 10 percent of all IAA results would be verified through lab analyses as part of a correlation study; the results of this correlation are presented in Appendix D.

Figure 3-22
Verification Sampling Equipment and Methods

- When the immunoassay showed greater than 1 ppm PCBs after a dredging pass, indicating a need for additional dredging, the sample was typically sent to an offsite lab for verification of PCB content to support the redredge decision. Exceptions to this process did occur, particularly when the immunoassay result indicated high PCB levels (e.g., 10-50 ppm). Toward the end of the dredging program, when laboratory turnaround times would have introduced delays in the dredging activities, decisions to conduct additional dredging were made on the basis of immunoassay results alone.
- If PCB concentrations greater than 50 ppm were encountered after the initial dredging pass, the cell was core sampled and analyzed to establish a new dredging design depth. A total of 19 cells were core sampled after laboratory results showed >50 ppm after the initial dredge pass. These cells were all cored to a depth of 16 inches, with retention of the 0-8 inch and 8-16 inch intervals for PCB analysis.
- When the immunoassay showed greater than 1 ppm PCBs after the second dredge pass (i.e., after it has been redredged), the decision whether to continue dredging was driven by the criteria identified in the flow sheet logic (discussed in Section 6).

As part of the process for verifying attainment of the ROD cleanup goals, expanded analyses for PAHs and PCDFs were conducted on a minimum of 10 percent of the dredge cells. Sediment samples for PAHs and PCDFs typically were collected at the same time that PCB samples were collected, and with the same methods.

RMC identified the cells for PAH and PCDF analyses using a randomized sampling approach as described in memos transmitted to the onsite EPA representatives on August 20, 2001 (*Selection of Final Verification Sampling Locations for Expanded Analyses, Evaluation Area #3*); September 10, 2001 (*Selection of Final Verification Sampling Locations for Expanded Analyses, Evaluation Area #2*); and October 1, 2001 (*Selection of Final Verification Sampling Locations for Expanded Analyses, Evaluation Area #1*). Figure 3-23 shows the locations of the cells selected for expanded analyses in all three areas.

The original intent was that the expanded analyses would only be conducted on cells where PCB results indicated <1 ppm PCBs; however, this was not feasible due to the persistence of PCB contamination in a number of the cells. For this reason, PAH and PCDF data were generated for some cells with PCB concentrations >1 ppm. Section 6 presents a detailed discussion of the PAH and PCDF sampling results.

The verification sampling activity was also augmented by the large number of split samples collected and analyzed by the onsite EPA and DEC representatives. The split sample jars were filled by the ATL sampling crew and turned over to the regulatory representatives for shipment to the laboratory. Results of the split sampling are also discussed in Section 6.1.

3.4 SHORELINE REMEDIATION

Shoreline remediation activities were conducted in 2 areas: along an approximate 600 ft section of Area C shoreline and an approximate 2,500 ft^2 area (50 ft *x* 50 ft) associated with the 008 outfall.

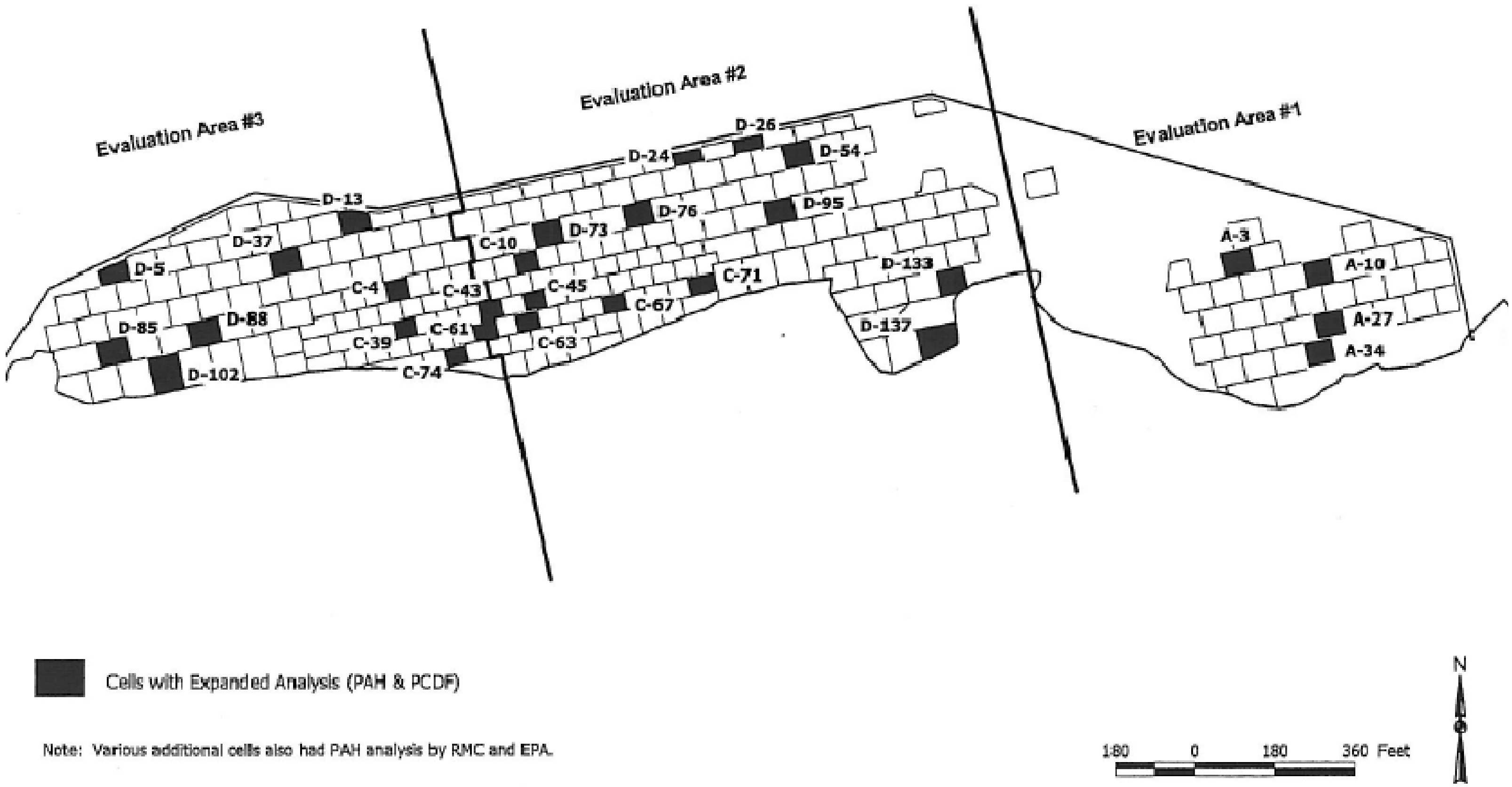


Figure 3-23
Locations for Expanded (PAH and PCDF) Analyses in Sediment Verification Samples

Area C Shoreline Excavation

Excavation of shoreline soils in Area C was completed in accordance with the Final Design. The areal limits of the excavation area were marked with stakes by the surveyors prior to excavation; the depth of excavation was 1 foot. The area to be excavated was expanded to include a 5-10 ft strip in the cells abutting the shoreline that was potentially inaccessible from the derrick barges. The limits of the sediment excavation from the shore were marked by the surveyors to guide follow-on dredging in the balance of the cells along the shoreline.

Soils excavated from the shoreline (above the water line) were loaded directly into trucks and transported to either the onsite landfill for disposal or sediment pens/river drying beds for stockpiling and characterization. Previous characterization of this material during the land-based remediation determined that this material had <50 ppm PCBs and was suitable for disposal in the onsite landfill; however, it was decided that only the uppermost bucket cuts taken farthest from the water's edge would be sent directly to the landfill. This decision was intended to minimize the potential for mixing Area C sediment in with the material being sent to the landfill.

Approximately 2,360 yd^3 of soil and sediment were excavated from the Area C shoreline. About 60 yd^3 were sent to the landfill (representing materials excavated with the uppermost bucket cut); all other material was sent to the sediment pens or river drying beds for stockpiling and characterization. Table 3-18 provides a breakdown of the quantities excavated and disposition of the materials.

Table 3-18
Quantities of Sediment Removed During Shoreline Excavation

Area	Onsite Landfill (cy)	Sediment Pens/Drying Beds (cy)
Shoreline remediation in Area C	60	2,310
Soil excavation at 008 outfall	150	--
Total Quantities	*210*	*2,310*

Near-shore sediment removed from the Area C cells along the shoreline was also directly loaded into trucks and hauled to the sediment pens or river drying beds for stockpiling and characterization sampling. This sediment is included with the total quantities of materials shown in the table above.

Excavation of 008 Outfall in Area D

Land-based remediation work had also identified an area of soil contamination associated with the western end of the Area D, adjacent to the auxiliary water intake peninsula. Contamination levels in this area were <50 ppm PCBs. The 2,500-ft^2 area was excavated to a depth of 1.5 ft using a trackhoe and loaded directly into trucks for disposal in the onsite landfill. Approximately 150 yd^3 of soil was excavated and sent to the landfill.

3.5 SEDIMENT HANDLING AND DISPOSAL

Sediment removed from the river bottom was transported to the East Dock via five material barges. The barges were positioned along either the northwest or east side of the dock so that a track-hoe located on the dock could access the sediment in the barge and transfer the material directly into a Terex dump truck. The final deposition of the material was based on the concentration of PCBs in the cell from which the material was dredged. Material removed from cells in which sample results indicated the concentrations were less than 50 ppm was transported to the onsite landfill located to the south of the Reynolds plant area. Material removed from areas or cells in which sample results indicated PCB concentrations greater than or equal to 50 ppm was transported to either the Sediment Storage Area or the River Drying Beds where the material was sampled. If the composite sample results were greater than or equal to 50 ppm PCB, the material was sent for offsite disposal. Material with sample results less than 50 ppm PCBs remained onsite and was brought to the landfill.

To ensure that sediment brought to the East Dock was disposed in the appropriate location, colored flags were used to indicate the type of material a barge or dump truck was hauling. Barges and dump trucks carrying material from cells less than 50 ppm of PCB had a blue flag attached while barges and trucks with material greater than or equal to 50 ppm PCBs had oranges flags attached. Barges and trucks carrying material with concentrations greater than 500 ppm PCB had black flags attached. The system enabled the proper disposition of each load of material.

3.5.1 Barge Unloading

River sediment was placed in one of five sediment barges. To remove the sediment from the barges, the barges were brought to the East Dock and placed alongside either the north or east face of the dock. The sediment was then removed from the barges with an excavator and placed directly into a Terex end dump truck (Figure 3-24). The barges were unloaded using one of three excavators:

1. 220 Komatsu Excavator with a 65 ft reach and a three-quarter cubic yard bucket,
2. 400 Komatsu Excavator with a 65 ft reach and 1.5 yd^3 bucket, or
3. Caterpillar 350 with a 50 ft reach and a 2.5 yd^3 clamshell bucket.

The dredged sediments were loaded directly into a Terex end dump truck on the East Dock. The trucks were brought onto the dock on wooden mats. The trucks are capable of hauling 30 tons; however, the trucks were only loaded to a maximum of about half their capacity, which was typically about 10 yd^3.

After loading a truck, the truck underwent a series of decontamination procedures. The outside of the dump was first sprayed with a Hotsy pressure washer to remove any sediment that may have splattered on the outside of the dump bucket. Prior to leaving the dock, a ratchet binder strap was attached to the tailgate to augment the existing rubber seals and further prevent leaking through the tailgate. A final inspection of the tailgate was performed to insure the gates were sealed and no leaking would occur. Depending upon the origin and PCB concentration of the material, the sediment was then hauled to either the on-site landfill, the Sediment Storage Area, or the River Drying Beds. The location of each of these destinations is shown in Figure 3-25.

3.5.2 Stabilization

Because of the high water content in the sediment removed from the river, it was necessary to dry and stabilize the wet sediment brought onshore prior to placement in the landfill or shipment to the offsite landfill. The volume of wet material brought onshore was too great to allow enough time to allow it to dry by itself. Field treatability studies were conducted in June 2001 to select the most appropriate dewatering agent. Tests were conducted with Portland cement, Quicklime, and cement kiln dust (CKD). These tests determined that Portland cement provided the best strength characteristics of the various admixtures. Air monitoring conducted during the treatability studies evaluated whether the addition of dewatering agents would generate any air emissions of concern. The results from this monitoring indicated that even under a worst-case scenario (e.g., measuring air concentrations in a closed container directly over the sediment), the mixture of contaminated sediment with Portland cement would not result in the release of airborne contaminants in concentrations above permissible exposure levels. It became necessary to apply Portland cement to the wet sediment to stabilize the material by accelerating drying of the material. The Portland cement also provided the added benefit of increasing the strength of the material that was placed in the landfill.

Figure 3-24
Sediment Unloading Operations at the East Dock

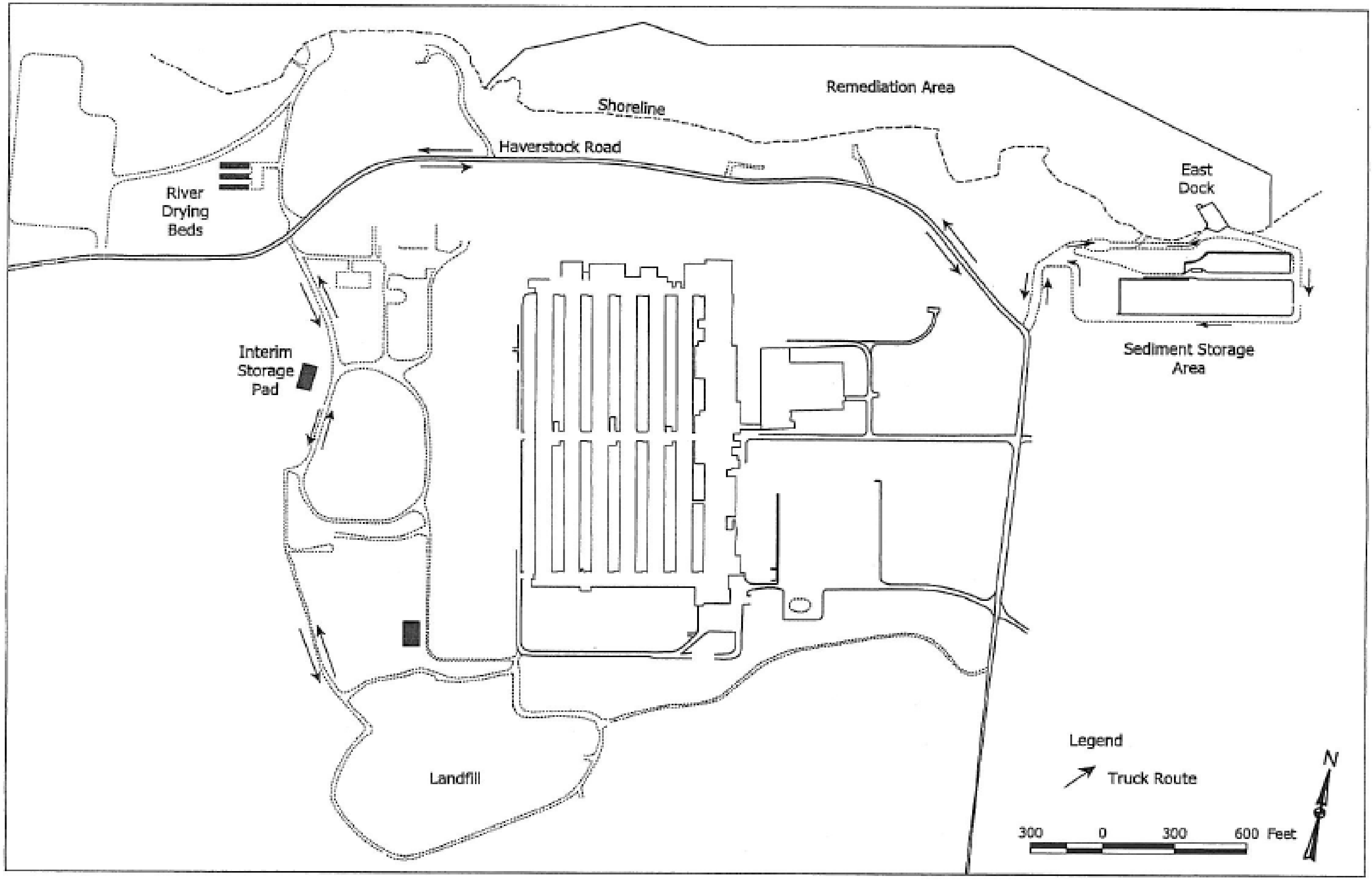


Figure 3-25
Onshore Sediment Handling Locations and Truck Traffic Patterns

All of the wet sediment removed from the river had to be stabilized with Portland cement. Sediment brought directly to the landfill was dumped into temporary mixing basins (excavated into the top of the landfill) where the cement was mixed into the sediment. Wet sediment brought to the Sediment Storage Area and the River Drying Beds was also stabilized in the holding pens with cement after sampling. The sediment that was determined to require offsite shipment (≥50 ppm PCB) had to be dried enough to pass the paint filter test prior to shipment. Sediment in stockpiles that were determined to have less than 50 ppm PCBs was transported to the onsite landfill after stabilization to avoid double handling of the wet sediment.

The Portland cement was applied on top of the wet sediment using an air-separator cyclone, which allowed the cement to be transferred pneumatically from the cement tanker to the wet sediment surface with minimal dust emissions (Figure 3-26). The cyclone unit dissipated the air pressure through filter bags and allowed the cement dust to fall through a 4-in. diameter tube onto the surface of the wet sediment. The cyclone was suspended from the bucket of an excavator with the discharge approximately 3 in. above the sediment surface.

After applying the cement to the surface of the sediment, an excavator was used to mix the cement and the sediment to a consistency that allowed the material to be consolidated into piles. The piles were typically not disturbed for at least one day to allow the Portland cement to better react with the water in the sediment.

A total of 13,144 tons of Portland cement were purchased to stabilize all of the sediment dredged from the river. Based on a density of 94 lb/ft^3 for Portland cement, the total volume of cement added to the sediment was 10,357 yd^3. This volume gives a total of 12.1% cement added to the wet sediment by volume and 15.3% by weight. This percentage is an average; the actual amount of Portland added to the sediment varied depending on the consistency (water content) of the sediment.

3.5.3 Sediment Handling And Disposal For <50 ppm PCBs

Sediment removed from cells with sample results indicating less than 50 ppm PCBs was loaded onto the Terex dump trucks and transported directly to the onsite landfill. After the truck was loaded and the outside of the truck was decontaminated, the sediment was then hauled around the south side of the Sediment Storage Area and then east on Haverstock Road. The road connecting Haverstock and the landfill was improved in 2001 prior to the start of dredging to accommodate two-way truck traffic. The truck route between the East Dock and the Reynolds Landfill are shown in Figure 3-25.

A total of 6,011 truckloads of wet sediment were brought to the landfill directly from the East Dock; 14 additional truckloads were brought to the landfill from shoreline remediation activities discussed in Section 3.4. As stated above, it was estimated that the average truckload of wet sediment was 10 yd^3, so the total quantity of wet sediment brought to the landfill was 60,250 yd^3. In addition to the sediment from the dredge cells with concentrations less than 50 ppm of PCB, about a third of the sediment taken to the Sediment Storage Area and River Drying Beds and stockpiled for characterization sampling was found to contain less than 50 ppm of PCB; this sediment was also taken to the onsite landfill. Figure 3-27 depicts the different ways in which the dredged sediment eventually reached the onsite landfill.

Figure 3-26
Stabilization of Wet Sediment using Cyclone, Track-Hoes and Portland Cement

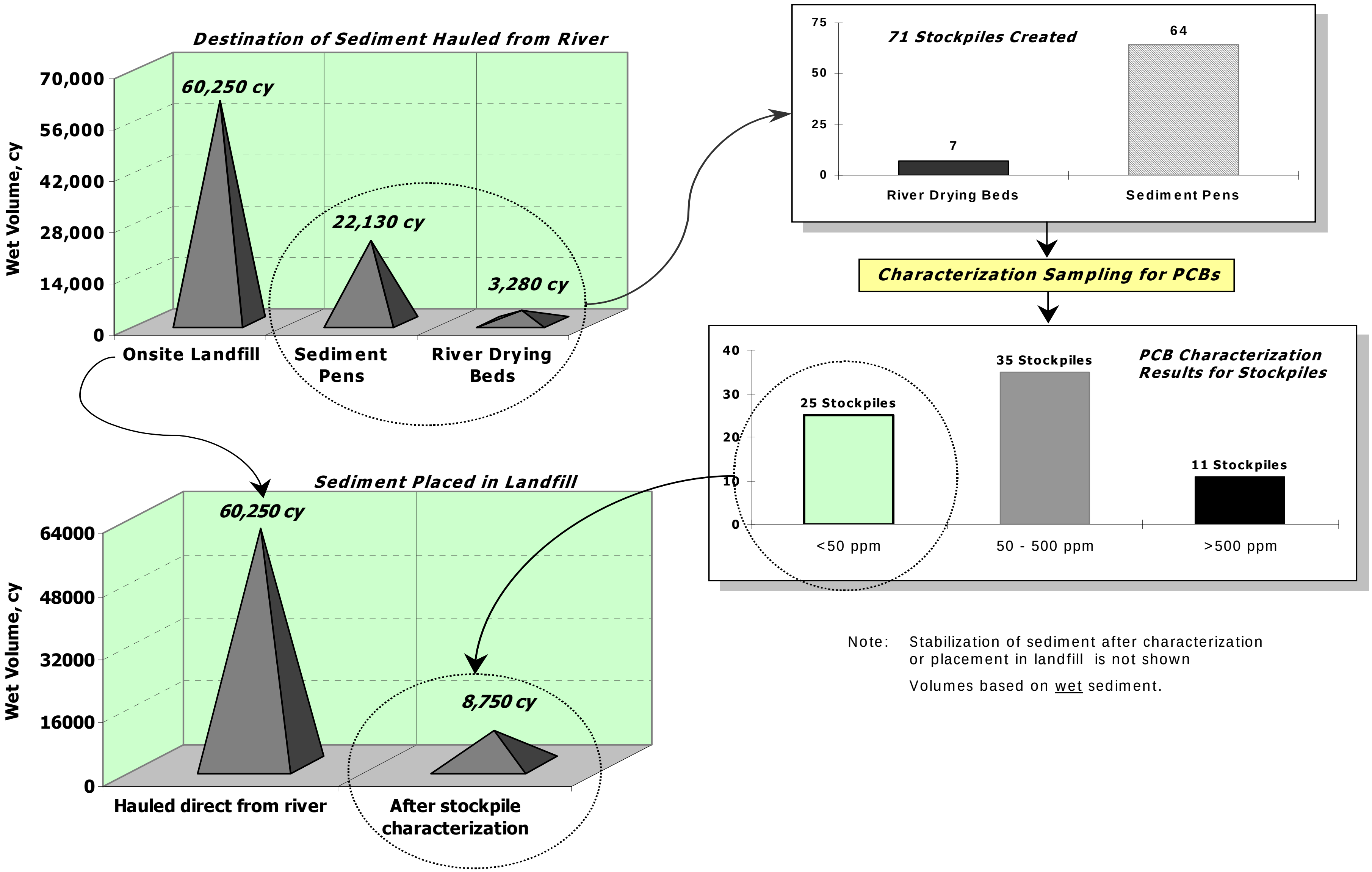


Figure 3-27
Derivation and Handling of Sediment Placed in Onsite Landfill

A total of 25 stockpiles (2 in the drying beds and 23 in the sediment pens), comprising 875 truckloads of wet material (8,750 yd^3), were determined to have less than 50 ppm PCBs. After sampling (described below), this material was stabilized with Portland cement and shipped to the landfill in 704 truckloads. The number of truckloads was less because the trucks could haul larger loads of stabilized material than wet sediment. Based on truck-count data, the total amount of sediment (wet volume) brought to the landfill, including that hauled directly to the landfill from the river and that making its way via the drying beds or sediment pens, was approximately 69,000 yd^3.

Wet material brought to the landfill was unloaded into one of the temporary mixing basins excavated into the top of the landfill to contain the wet sediment. The wet sediment was then stabilized in the basins by mixing Portland cement with the sediment. After enough cement dust was mixed with the sediment to achieve a manageable consistency, the sediment was removed from the basin and placed in piles where it was allowed to sit for a couple of days before forming into a lift. Sediment from stockpiles in the Sediment Storage Area or River Drying Beds shown to have <50 ppm PCBs was stabilized prior to transport to the landfill; this material was dumped into piles on the landfill.

The stabilized material was removed from the piles and placed in 8-in. lifts with bulldozers and compacted with a drum roller (Figure 3-28). After the material was compacted, geotechnical tests were performed on the in-place lift to determine whether it met the required compaction and strength required for the landfill. The soil compaction was measured using a Troxler nuclear density device and the soil strength was measured with a hand-held penetrometer. The target for compaction of the material in the landfill was 85% of the maximum dry density of the material, and the target for the strength of the material was 0.3 tsf. Figure 3-29 provides a plot of the locations of each of the soil tests that passed with greater than 85 percent compaction. All of the strength tests had greater than 4.5 tsf.

To determine the maximum dry density of the sediment being placed in the landfill, laboratory compaction tests (ASTM D 1557) were performed on sediment samples from material barges; the results are listed in Table 3-19. In-place tests of the soil were performed to ensure the compaction of each lift in the landfill was at least 85% of 116 lb/ft^3.

Table 3-19
Sediment Laboratory Compaction Test Results

Sample Date	Moisture Content (%)[a]	Maximum Dry Density (lb/ft^3)[b]	Optimum Moisture Content (%)[b]
June 15, 2001	167.2	116.0	14.5
June 29, 2001	--	135.5	8.5
July 10, 2001	89.9	120.0	14.0

a – ASTM D 2216
b – ASTM D 1557

During the placement of the material in the landfill, topographic surveys were performed on a monthly basis and compared with a survey that was performed in December 2000.. The final topographic survey was performed in November 2001 after all of the material from the 2001 construction season had been placed in the landfill. Plots of the landfill contours in December 2000 and November 2001 are shown in Figure 3-30. Based on the difference between the two topographic surveys, the volume of material placed in the landfill is calculated to be 50,300 yd^3. This volume is 27% less than the wet volume of 69,000 yd^3. The difference is attributed to the effects of stabilization, placement, and compaction of the material.

Figure 3-28
Landfill Operations

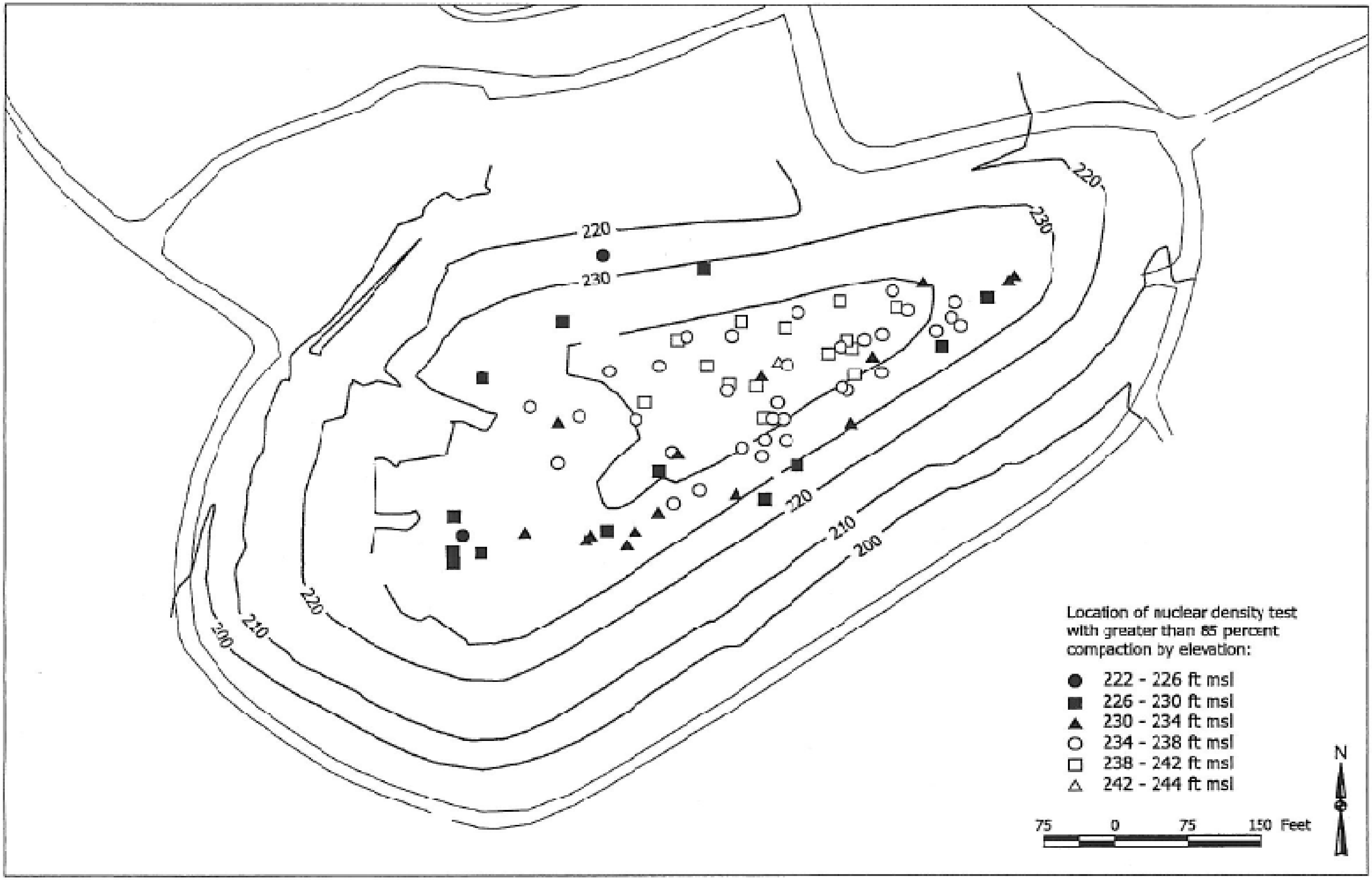


Figure 3-29
Compaction Testing at On-Site Landfill

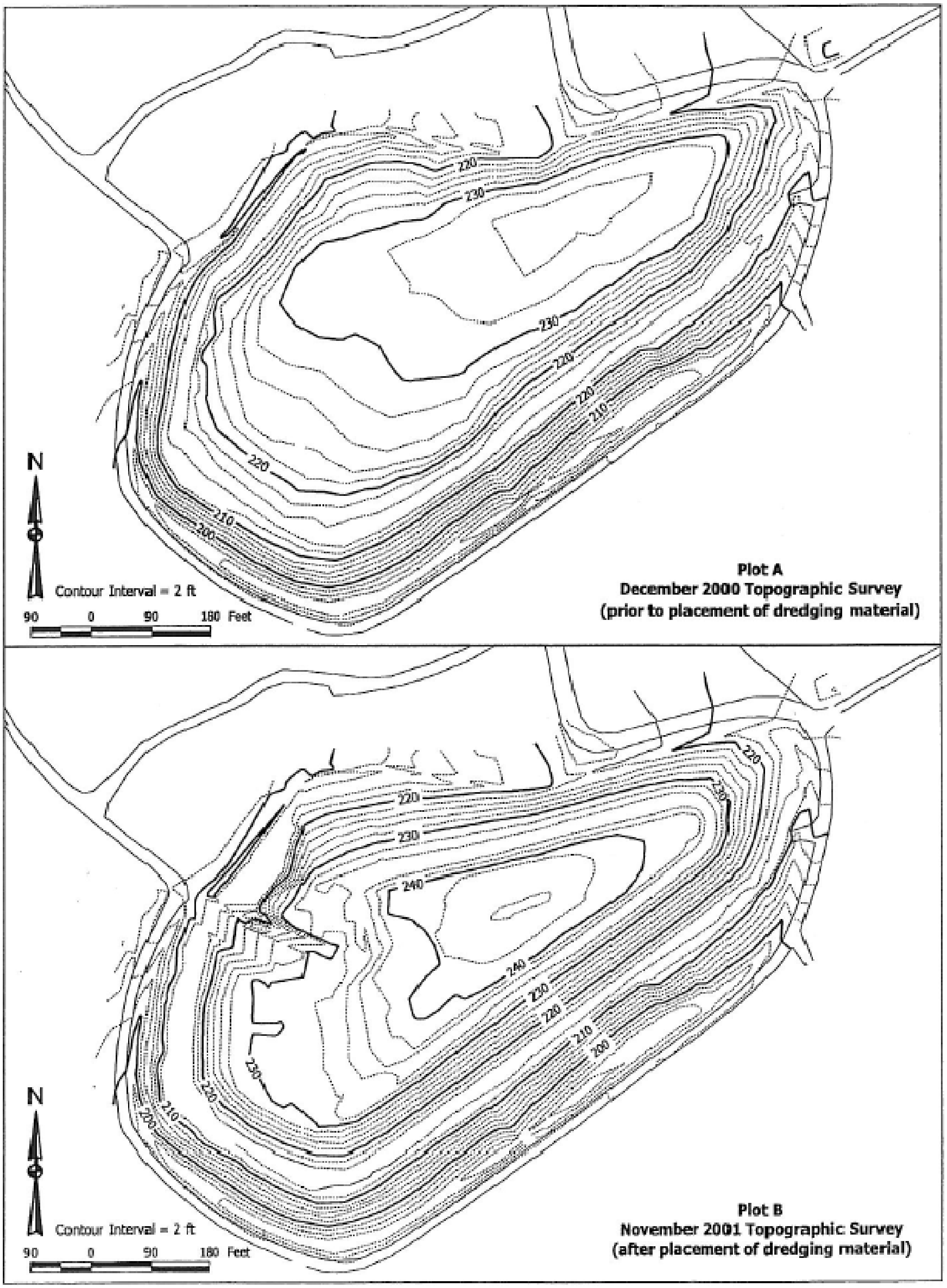


Figure 3-30
Topographic Survey of RMC Landfill

3.5.4 Sediment Handling and Disposal For ≥50 Ppm PCB Material

Sediment dredged during the initial pass through Area C or from any cells where sample results indicated greater than or equal to 50 ppm PCBs was transported to the sediment pens or drying beds for stockpiling and characterization sampling to determine final disposition.

A total of 2,541 loads of wet sediment (25,410 yd^3) were brought to the Sediment Storage Area or River Drying Beds from either the East Dock or from shoreline remediation activities in Area C. Of this number, 105 truckloads were from the dredging of the original hot spots (>500 ppm PCBs), and an additional 53 loads were from cells in which the verification samples later identified sediment with >500 ppm PCBs. The remaining 2,383 truckloads were from the first pass of area C cells, from cells whose verification sample results were between 50 and 500 ppm, or from sediment that was dredged along the silt curtain alignment.

The River Drying Beds were designated for stockpiling sediment dredged from the >500 ppm hot spots. The three beds were each 122 ft long by 26 ft wide and approximately 4 ft deep. A sand layer overlain by a filter fabric was at the bottom of the bed and was used to collect leachate from the sediment. Leachate from the sand layer was collected in a sump, which was pumped out and treated at the wastewater treatment plant in the Sediment Storage Area.

The Sediment Storage Area was composed of a 3.4-acre, bermed asphalt pad. The pad contained 17 sediment pens used to stockpile wet sediment for sampling and stabilization. The pens were constructed with movable Jersey barriers that were 2.67 ft high. The dimensions of the pens changed throughout the project to provide additional volume for the wet sediment; however, the typical dimensions for a pen were 52 ft by 65 ft. Figure 3-31 provides a generalized plot of the location of each of the sediment pens. Drainage and storm water runoff from the sediment pens was collected by the berms or ditches and directed to one of two specially-constructed and lined holding basins. The wastewater treatment plant treated the water in the basins and discharged it back into the river (inside the sheet pile enclosure) in accordance with a NYSDEC discharge permit.

Sediment brought to both the Sediment Storage Area and River Drying Beds was placed in a sediment pen or drying bed, forming a stockpile, and sampled in accordance with *REP-014, Procedures for Collecting Composite Samples of Dredged Sediment*. The procedure entailed the collection of a representative composite sample for PCB analysis (Figure 3-32). Composite sampling involved the collection of 10 increment grab samples from each pile. Each increment was obtained either directly from the pile or from the excavator bucket, which was used to grab sediment from part of the stockpile that was not accessible to the sampling team. The 10 increments were selected from random locations across the stockpile and represented both the surface and internal material within the pile. Approximately 22 lb of sediment were collected for each increment. The material was combined in a cement mixer and thoroughly mixed (homogenized). The resulting mixture was then passed through a 3/16-in. screen to remove small rocks and debris. Sample jars were filled from the resulting homogenized and screened material.

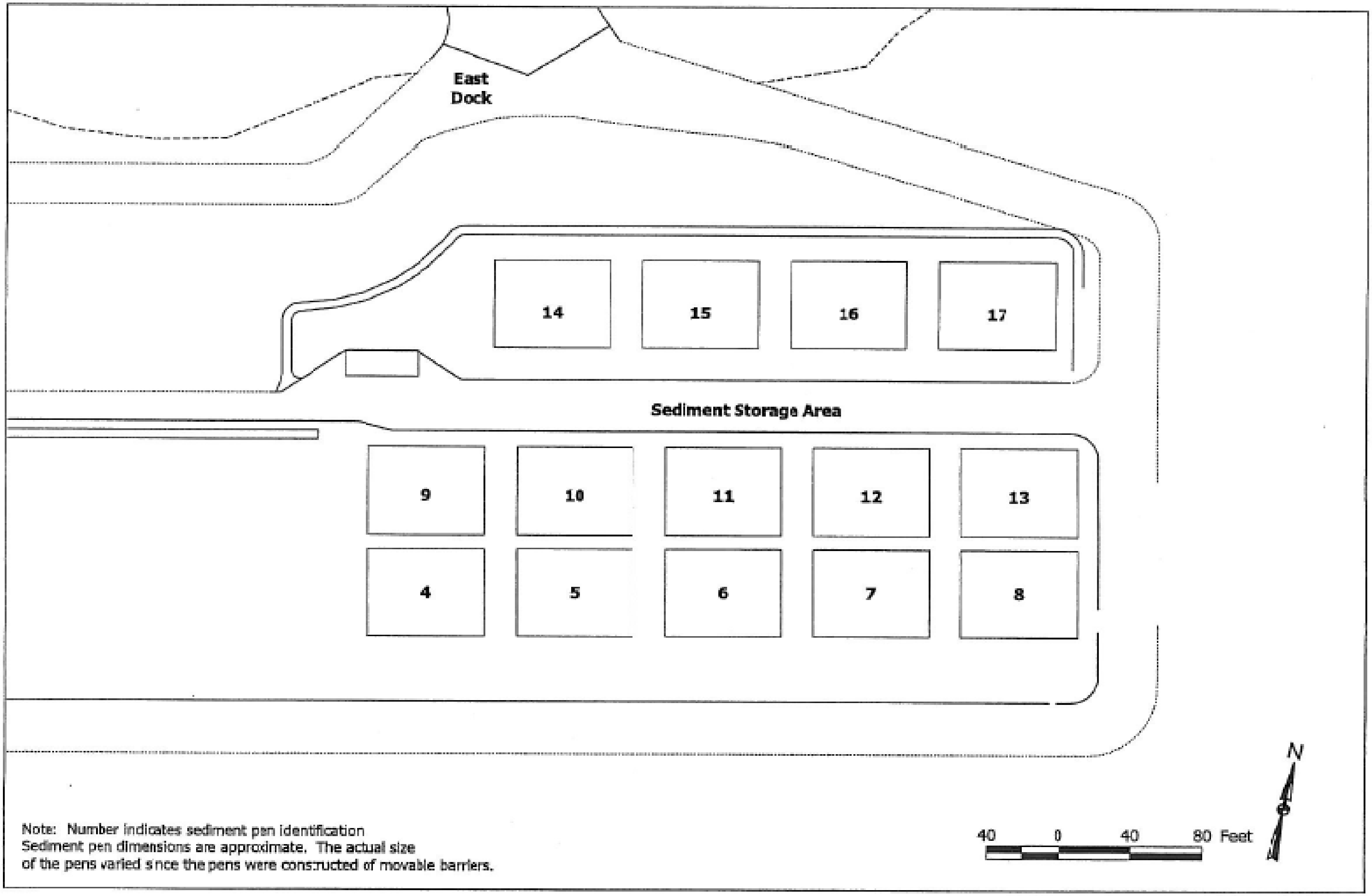


Figure 3-31
Layout of Sediment Pens

Figure 3-32
Composite Sampling Methods

The resulting "characterization" sample was sent to an offsite laboratory for PCB analysis, and the destination of the material was then decided based on the sample results. A large number of split samples were collected from the characterization samples by DEC and EPA. When this occurred, the highest sample result among the split samples determined the ultimate disposition of the material. It is also important to note that stabilization was conducted <u>after</u> the stockpile characterization samples had been collected. Characterization samples were not collected from stabilized sediment.

Stockpiles of material yielding characterization samples with PCB concentrations less than 50 ppm were sent to the onsite landfill for disposal. These sediments were stabilized in the drying bed or sediment pen prior to transport to the landfill. Stockpiles of material with PCBs equal to or greater than 50 ppm were sent for offsite disposal at ChemWaste's Model City facility near Buffalo, New York, a TSCA-approved landfill. These sediments were also stabilized prior to loading into trucks for offsite shipment (Figure 3-33). Further discussion of sediment stabilization for sediments shown to have >500 ppm PCBs is discussed below.

A total of 64 stockpiles were created and sampled in the sediment pens; Table 3-20 lists the characterization results for these stockpiles. The table also includes the volume per stockpile (shown as truck counts) and the PCB mass of the stockpile, based on the volume, characterization sample, and assumed sediment density of 76 pcf.

Figure 3-33
Offsite Shipment of Stabilized Sediment to Model City

Table 3-20
PCB Concentrations and Mass in Sediment Storage Area Stockpiles

Pen No.	Sample Date	# of Truckloads	PCB Conc. (ppm)	PCB Mass (lbs)	Destination
4	7/25/01	37	7.5	5.70	Landfill
4	8/1/01	28	68.3	39.23	Offsite
5	7/26/01	48	53.8	53.03	Offsite
6	7/25/01	26	9.4	5.03	Landfill
6	8/4/01	25	480	246.24	Offsite
7	7/27/01	21	1.8	0.79	Landfill
7	8/6/01	24	291	143.31	Offsite
8	7/27/01	31	0.5	0.32	Landfill
8	8/7/01	32	42.8	28.10	Landfill
9	7/20/01	31	98.4	62.59	Offsite
9	7/27/01	34	27.3	19.06	Landfill
9	8/1/01	34	59.0	41.17	Offsite
9	8/7/01	33	32.8	22.23	Landfill
9	8/30/01	37	978	742.54	Offsite
9	--	30	50 [a]	30.78	Offsite
10	7/21/01	35	18.9	13.60	Landfill
10	7/26/01	36	170.1	125.65	Offsite
10	7/31/01	45	17.0	15.67	Landfill
10	8/3/01	33	610	413.07	Offsite
10	--	17	50 [a]	17.44	Offsite
11	7/23/01	30	64.6	39.77	Offsite
11	7/26/01	45	42.7	39.41	Landfill
11	8/1/01	39	71.7	57.36	Offsite
11	8/8/01	41	4760.3	4,004.91	Offsite
11	--	45	50 [a]	46.17	Offsite
12	7/23/01	45	36.2	33.39	Landfill
12	7/30/01	41	391.2	329.12	Offsite
12	8/4/01	40	650	533.52	Offsite
12	9/26/01	68	900.0	1,255.77	Offsite
13	7/23/01	29	5.7	3.38	Landfill
13	7/27/01	40	5.1	4.20	Landfill
13	8/3/01	35	256	183.86	Offsite
13	8/10/01	46	130.5	123.18	Offsite
13	9/4/01	35	570.8	409.98	Offsite
13	--	47	50 [a]	48.22	Offsite
14	6/29/01	25	0.87	0.45	Landfill
14	7/18/01	31	55.3	35.15	Offsite
14	7/24/01	48	15.2	15.01	Landfill
14	7/28/01	30	5.1	3.11	Landfill
14	8/2/01	46	132	124.60	Offsite
14	8/8/01	36	49.7	36.73	Offsite
14	8/25/01	23	82.1	38.74	Offsite
14	9/4/01	23	110	51.92	Offsite
14	9/27/01	14	350.2	100.59	Offsite
14	10/17/01	33	152.5	103.26	Offsite
15	7/12/01	11	0.81	0.18	Landfill
15	7/18/01	32	92.6	60.78	Offsite
15	7/25/01	34	18.9	13.16	Landfill
15	7/30/01	45	132.6	122.39	Offsite
15	9/14/01	44	213.0	192.31	Offsite
15	10/16/01	29	122.0	72.59	Offsite
16	7/12/01	10	26.6	5.45	Landfill
16	7/19/01	27	99.0	54.84	Offsite
16	7/28/01	35	26.7	19.16	Landfill
16	8/2/01	29	143	85.10	Offsite
16	8/10/01	39	2700	2,160.76	Offsite
16	--	23	50 [a]	23.60	Offsite
16	10/6/01	32	2468.6	1,620.97	Offsite
17	7/20/01	24	84.5	41.61	Offsite
17	7/24/01	34	14.9	10.40	Landfill
17	7/28/01	47	35.2	33.98	Landfill
17	8/7/01	54	47.1	52.23	Landfill
17	8/28/01	37	3443	2,614.06	Offsite
17	10/15/01	55	81.7	92.17	Offsite

a – Stockpile not sampled; material dredged from the silt curtain corridor, stabilized, & shipped offsite. An assumed concentration of 50 ppm was used for the mass calculation.

A total of seven stockpiles were created and sampled in the River Drying Beds. Table 3-21 lists each stockpile and characterization sampling results from the drying beds. The table includes the estimated PCB mass associated with each drying bed stockpile.

Table 3-21
PCB Concentrations and Mass in River Drying Bed Stockpiles

Bed No.	Sample Date	PCB Conc. (ppm)	PCB Weight (lb)	Destination
1	7/19/01	57.231	58.71901	Offsite
1	10/5/01	697.399	715.5314	Offsite
1	10/16/01	40.258	41.30471	Landfill
2	7/17/01	<500 [a]	256.5	Offsite
2	7/21/01	11.05	11.3373	Landfill
2	8/9/01	665.994	683.3098	Offsite
3	7/17/01	<500 [a]	256.5	Offsite

a – The concentration was nondetect at 500 ppm. An assumed concentration of 250 ppm was used for the mass calculation.

The number of truck counts per river bed stockpile was not available since the drivers typically did not identify the specific beds into which the offloaded material was placed. The total number of truckloads hauled to the River Drying Beds was 328, which is estimated to be 3,280 yd^3. The average volume per stockpile was then estimated by dividing the total volume by the number of stockpiles. The average volume was estimated to be 469 yd^3. The beds were designed to hold 500 yd^3 stockpiles and thus the estimated value is probably reasonably accurate. The PCB weight for each stockpile was calculated using the average volume.

Figure 3-34 shows the distribution of stockpile characterization sampling results by PCB concentration; the chart includes results from the 64 stockpiles created in the sediment pens and 7 stockpiles from the drying beds.

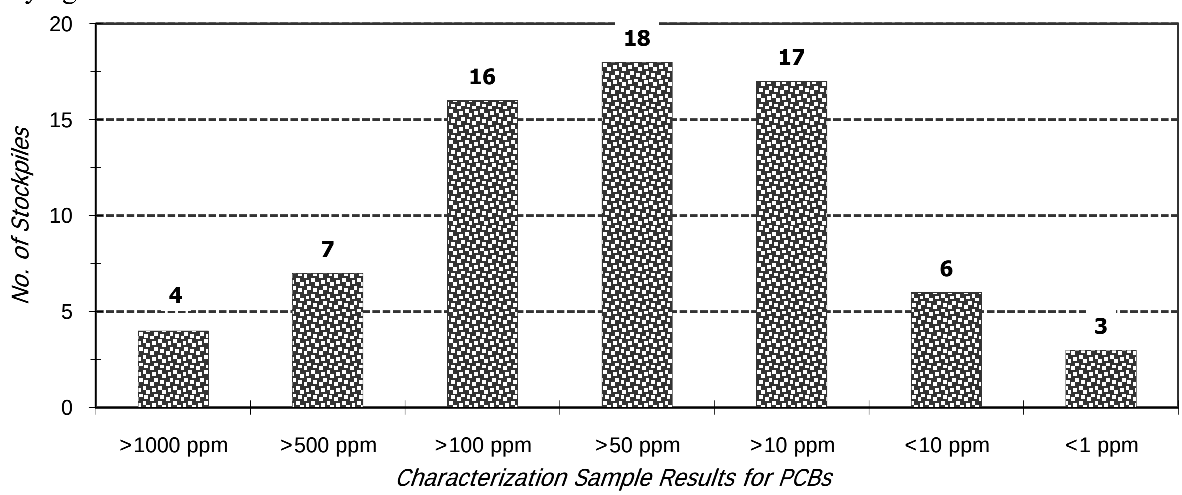


Figure 3-34
Distribution of Stockpile Characterization Results by Concentration

The majority (63%) of the stockpile characterization samples had PCB concentrations greater than 50 ppm PCBs. The 26 stockpiles with concentrations less than 50 ppm PCBs include a sample from Pen 14 collected on August 8, 2001 that had 49.7 ppm; this sample was so close to 50 ppm that it was sent for offsite disposal. PCB concentrations of less than 50 ppm in the stockpiles were not unexpected, given the variability in the contaminant distribution within the sediment and the absence of pre-dredging contaminant data from many of the cells in Area C.

Table 3-22 presents data concerning the distribution of stockpiles by PCB mass. More than 61% of the PCB mass removed through sediment stockpiled in either the sediment pens or drying beds was associated with only five stockpiles. PCB concentrations in these five piles ranged from 900 to 4,760 ppm. Relatively little PCB mass was removed through stockpiles with PCB concentrations less than 50 ppm PCBs—these 17 stockpiles had, on average, only about 17 lb of PCBs in each pile.

Table 3-22
PCB Mass in Stockpiled Sediment

	Stockpiles		**PCB Mass**	
PCB Mass per Stockpile	**Number**	***% of Total***	**Total (lbs)**	***% of Total***
>1,000 lbs of PCBs	5	*7*	11,656	*61*
>100 lbs of PCBs	19	*27*	5,806	*31*
>10 lbs of PCBs	37	*52*	1,456	*8*
<10 lbs of PCBs	10	*14*	29	*<0.15*
Total	71	*100*	18,946	*100*

A total of 46 stockpiles from the Sediment Storage Area and River Drying Beds were shipped for offsite disposal, and 25 stockpiles were sent to the onsite landfill. Of the 46 stockpiles sent for offsite disposal, 11 had PCB concentrations greater than 500 ppm. Figure 3-35 illustrates the disposition of each stockpile and also provides a breakdown of volume of sediment (wet) in the Sediment Storage Area and River Drying Beds by destination. The volume of sediment shipped to the onsite landfill was 34% of the total volume that went through the sediment pens and drying beds.

The total weight of the stabilized sediment that was shipped to the offsite disposal facility is 22,356 tons. Of this weight, 16,447 tons of the material was from stockpiles that had greater than or equal to 50 ppm PCBs. The remaining 5,909 tons were from stockpiles that had greater than 500 ppm PCB; this material is further discussed below. A total of 553 truckloads of material, each carrying about 30 tons, were used to transport the stabilized, ≥50 ppm material to Model City. This material was properly manifested and transported without incident—no spills, leaks, traffic accidents, or other problems. Disposal at Model City was conducted in accordance with the facility's EPA and DEC permits (including a TSCA permit for disposal of PCBs) that govern its operations.

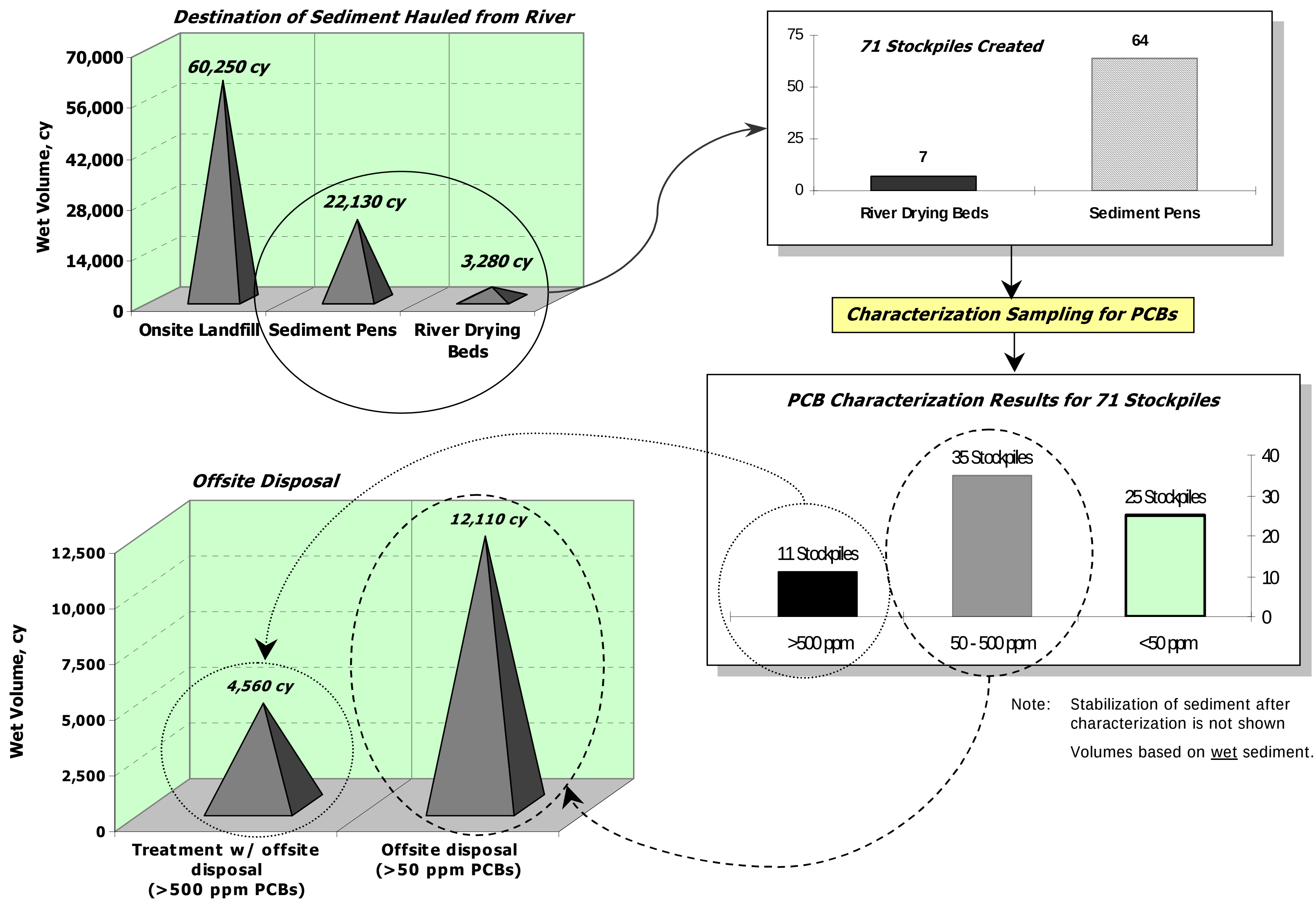


Figure 3-35
Derivation And Handling Of Sediment Stockpiles Sent For Offsite Disposal

3.5.5 Treatment and Disposal of >500 ppm Material

In accordance with the ROD and subsequent agreements with EPA, dredged sediments with PCB levels exceeding 500 ppm were to be treated prior to disposal of any residuals at a TSCA-approved facility. Treatment of the >500 ppm material was documented in the ROD to be consistent with the EPA's *Guidance on Remedial Actions for Superfund Sites with PCB Contamination* with respect to remediation of PCB "principal threats" at Superfund sites. The PCB guidance document recommends treatment of materials with PCB concentrations exceeding 500 ppm.

Removal of sediment from the >500 ppm hotspots occurred during the period July-October 2001. After dredging, the material was unloaded and stockpiled in either the Sediment Storage Area pens or River Dewatering Beds. The PCB content of the material was determined in accordance with the composite sampling procedure for stockpiled material (REP-014). Data quality for the PCB results is considered excellent given that numerous sample splits with the NYSDEC were conducted. Where a discrepancy occurred between the different labs, the highest laboratory result was used to classify the material.

Approximately 4,560 yd^3 of wet sediment were eventually determined to have greater than 500 ppm PCBs. This material was obtained primarily from Area C, with the majority coming from dredge cells near the former 001 outfall. The original estimate, prepared during the design phase of the project, anticipated about 4,000 yd^3 of sediment with >500 ppm PCBs.

The treatment technology utilized for the >500 ppm material involved the onsite application of the solidification/stabilization (S/S) process. Solidification is defined as a treatment process where contaminants are physically bound or encapsulated to form a solid material that restricts contaminant migration by decreasing surface area or coating the waste with low-permeability materials. In stabilization, chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility.

Portland cement was used as the S/S binding agent for the >500 ppm material. Portland cement is recognized by EPA as a viable S/S technology due to the chemical reactions that occur between the cement and any entrained moisture or water in the waste matrix. According to the EPA publication *Solidification/Stabilization Use at Superfund Sites* (EPA-542-R-00-010), cement has been the most widely used binder or reagent in S/S projects. Use of Portland cement in the S/S process involves chemical reactions that form a solid, cementitious matrix that immobilizes contaminants while also improving the handling and physical characteristics of the waste.

According to information in the EPA publication cited above, S/S has been used to treat PCBs (as either the primary contaminant or one of the major contaminants) at a total of 31 Superfund sites through 1998. These data indicate that there is significant precedent in the use of S/S for treatment of PCB-contaminated materials, and that S/S of the >500 ppm sediment satisfies the EPA preference for treatment of principal threat wastes.

Treatment of the >500 ppm material began in August 2001. Tanker trucks containing Portland cement (~26 tons of cement per tanker load) were moved into position adjacent to the stockpiled sediment. The Portland was transferred to the stockpiles using a tractor-mounted blower and cyclone. After transfer, the cement was mechanically mixed into the sediment using a track-hoe bucket. As described above, stabilization entailed the addition, on average, of 15.3% by weight of Portland cement. The addition of this quantity of Portland has significantly improved the handling characteristics of the sediment and resulted in the creation of a well-stabilized, high strength solid that is readily transported and placed into a secure disposal facility.

After mixing, the stockpiles were consolidated into larger stockpiles and eventually moved into secure storage configurations at the interim storage pad and river dewatering beds. In the course of moving the material for storage, additional Portland cement was added to enhance the handling characteristics of the material. The quantity of Portland added during this secondary consolidation step was dependent upon the residual moisture content of the material. This additional cement was accounted for in the mix ratios discussed above.

Following addition of the Portland cement and a thorough mixing of the cement into the sediment, the stabilized material was covered during the curing period to control dust and/or odors. Curing continued until the material was transported to the offsite disposal facility. The minimum cure time was approximately 2 weeks; much of the material had a cure time approaching 6 weeks or more.

The treated sediment with >500 ppm PCBs was loaded and transported to ChemWaste's Model City disposal facility near Buffalo, New York for landfilling in accordance with the facility's TSCA permit for disposal of PCB-contaminated material. Model City is a secure disposal facility designed and permitted to handle untreated PCB wastes with similar or even higher PCB concentrations than that present in the treated sediment shipped from the RMC site. A total of 203 truckloads carrying 5,909 tons of stabilized sediment with >500 ppm PCBs was eventually shipped to Model City. Mass calculations estimate that this material contained 15,154 lbs of PCBs.

Figure 3-36 presents a summary of the dredging, handling, temporary storage, treatment and disposal activities conducted for the >500 ppm sediment.

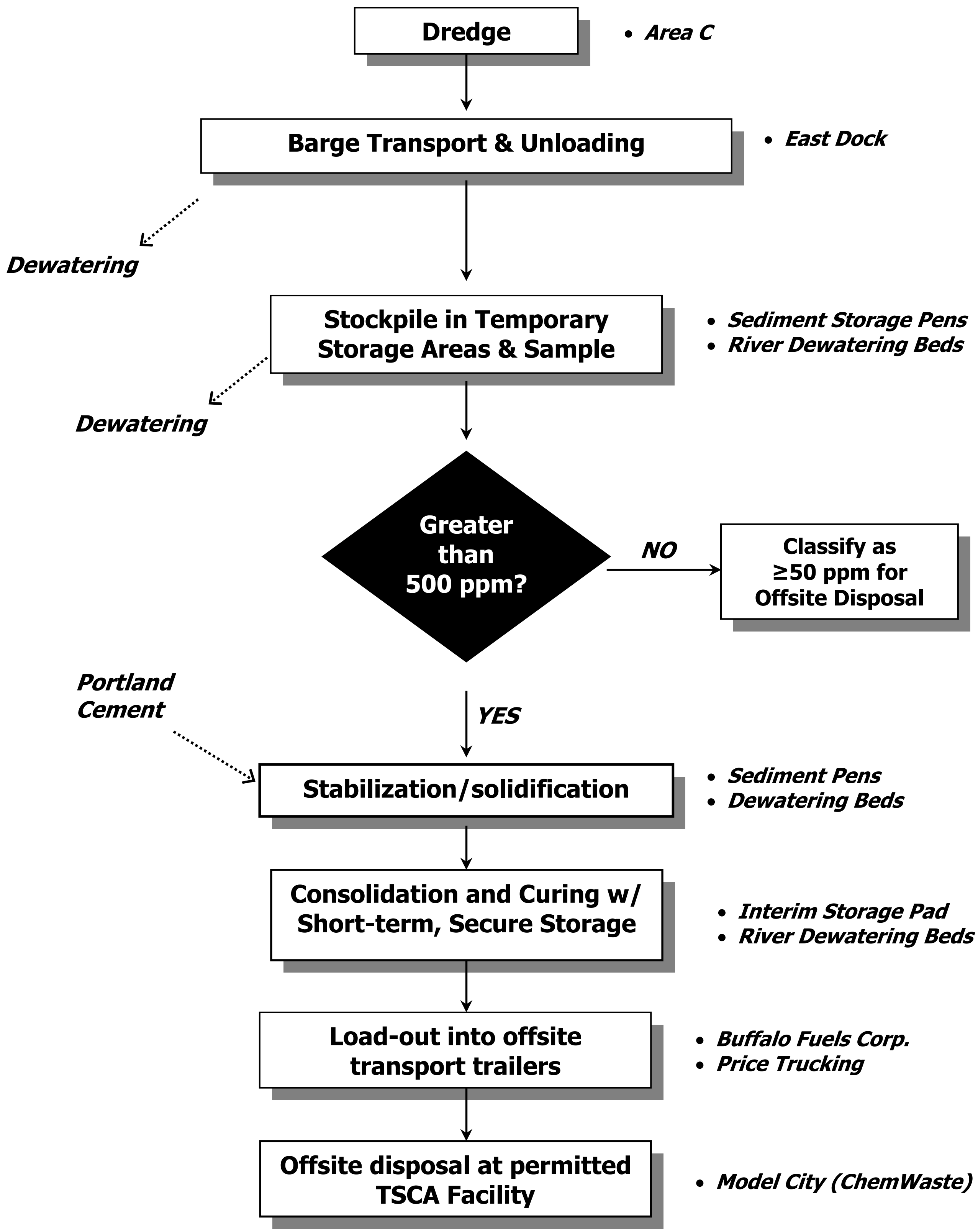


Figure 3-36
Process Flow chart for Generation, Characterization and Disposition of >500 ppm Material

3.6 INTERIM CAPPING OF DREDGE CELLS

A total of 15 dredge cells were covered with an interim cap at the conclusion of the dredging work in 2001. Capping was completed in accordance with the procedures identified in the EPA-approved *Work Plan for Interim Capping of Area C Cells with >10 ppm PCBs*. Only 12 of the cells had PCB concentrations exceeding the 10 ppm criterion for capping that was identified in the Final Design. The other 3 cells were capped by virtue of being essentially surrounded by cells that needed to be capped, and it was easier from a material placement and verification perspective to include these under the cap. Table 3-23 lists the cells that were capped; cells locations and the configuration of the interim cap are shown in Figure 3-37.

Table 3-23
Dredge Cells Covered with Interim Cap in 2001

Cell	PCBs, ppm	Dredge Passes	Eval. Area
C-27	11.4	3	2C
C-41	19.4	7	3C
C-42	24.0	7	3C
C-43	28.1	7	2C
C-44	44.2	10	2C
C-45	14.1	6	2C
C-46	11.1	1	2C
C-62	4.2	8	2C
C-63	7.1	7	2C
C-64	1.5	4	2C
C-65	14.7	1	2C
C-76	120.4	7	2C
C-77	75.3	4	2C
C-78	20.1	4	2C
C-86	11.1	1	3C

Note: Capping criterion identified in Final Design was 10 ppm PCBs

As shown in Figure 3-37, the cap design called for “runout” into adjacent cells, which resulted in portions of 22 additional cells being capped. None of these cells were covered in their entirety, (although C-61 was close [~75%]), and thus none of these 22 cells were included in the list of capped cells or treated as capped cells in the evaluation of remediation completeness (see Section 6).

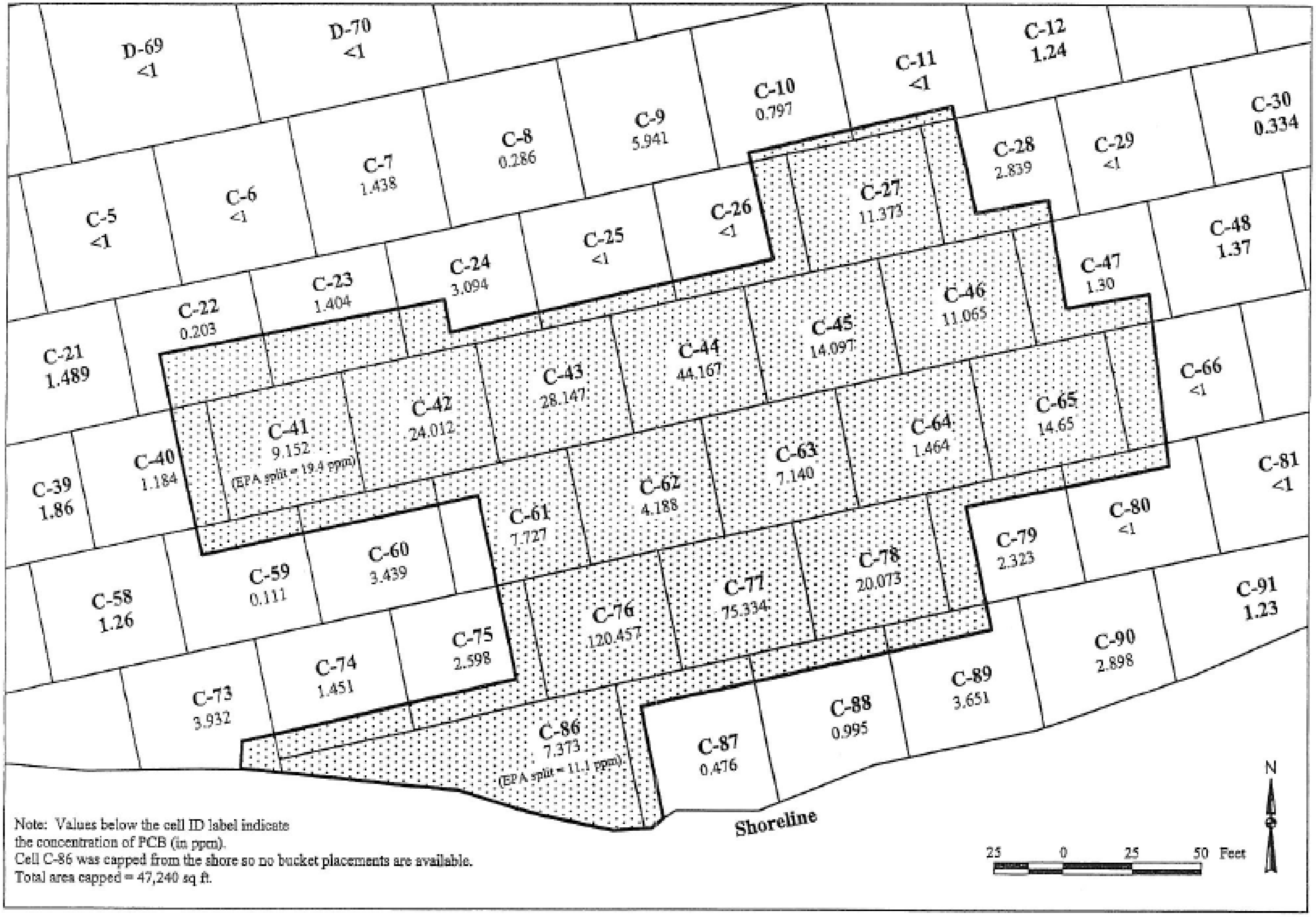


Figure 3-37
Capped Cells and As-built Dimensions of Cap

3.6.1 Design of Interim Cap

The material placed for interim capping was based on the physical isolation layer as detailed in the EPA-approved *Subaqueous Cap Design Plan* presented in the *Remedial Action Work Plan* (Bechtel 2001a). The layer serves to physically isolate the underlying sediments and also provides a barrier against bioturbation of the underlying sediments. The design specified that the layer consist of a 6-in. (minimum) layer of gravel. For the purposes of this application, EPA requested that the minimum thickness of the layer be increased to 12 in., and that the gravel be placed in two lifts.

Per the design, the cap had to be go beyond the boundary of the cell (or area) being capped ("runout") for a minimum of 5 times the layer thickness. For a 12-in. layer, the cap would be extended a minimum of 5 ft beyond the boundary. For this application, the capping material was placed a distance of 10 ft beyond the cell boundary to allow for the most efficient pattern of barge movement, boom movement, and bucket placement operations.

The design specification for the gravel is that 100% must be finer than 1 in. and no more than 15% of the material can be less than 1/8 in. in size. According to the specifications, stone meeting the size gradation requirements for NYSDOT Size Designation 1A is acceptable, and this is the type of stone that was used for construction of the gravel layer. The 1A gravel was washed prior to delivery to minimize turbidity during placement.

3.6.2 Cap Installation

Prior to mobilization of equipment to the capping area, the limits of the cap, including the runout, were identified and marked with buoys using GPS surveying equipment. The gravel layer was placed using of the Cat 350 positioned on a sectional barge (Figure 3-38). The gravel was loaded onto a material barge and towed out to the capping site for placement by the Cat 350 using a hydraulic clamshell bucket with a 2.5 yd^3 capacity.

A barge-mounted GPS receiver and the WINOPS software utilized for dredging. This system allowed for positioning of the barge over the cells to be capped as well as tracking of barge movement and bucket placement as capping progressed. Appendix B presents capping progress figures that depict barge location and bucket patterns that show where each bucket of gravel was placed. The bucket pattern was based on a bucket spacing of 6.4 ft to obtain a minimum of 6 in. per lift.

Placement of the capping material was conducted in accordance with the procedure described in the capping work plan. Additional details concerning the implementation of these procedures are presented in Appendix B.

Approximately 6,717 tons of gravel were used in capping the designated area. Using a conversion factor of 1.5 tons per cubic yard, this is equivalent to 4,478 yd^3 of material. Daily bucket-log counts using a conservative value of 2.15 yd^3 per bucket documented placement of 4,059 yd^3 of material with the Cat 350 over an area of approximately 47,240 ft^2. The remainder of the material was placed on cells C-86, C-87, C-73, C74 and C-75 from shore using an excavator.

Figure 3-38
Capping Operations and As-Built Appearance of Capped Cells

The gravel was placed directly on the river bottom. The *Subaqueous Cap Design Plan* called for the placement of a geotextile fabric between the underlying sediment and separation layer whenever the cap was to be placed over soft sediment. As shown in the cell status report (Appendix C), this area was the focus of repeated dredging activities (in some cases as many as 10 dredge passes) that removed all of the soft sediment from the area. Given the absence of soft sediment in the area to be capped, the bottom did not need to be covered by geotextile prior to placement of the gravel.

3.6.3 Placement Verification

As stated above, the areal dimensions of the as-built capped area, including runout, was 47,240 ft^2. Daily checks on the accuracy of the DGPS system confirmed that the spatial data being collected during the capping operations were accurate. The bucket placement logs generated by WINOPS and presented in Appendix B, therefore provided a high level of confidence regarding the areal limits of the cap. In addition, the boundaries of the capped area were marked with buoys, which allowed visual confirmation of gravel placement to the limits of the cap.

The gravel was placed more or less evenly over this area, based on an evaluation of the capping progress figures. Dividing the total volume of gravel placed (4,478 yd^3) over this area, the resulting average thickness of the gravel layer was calculated to be about 2.2 ft.

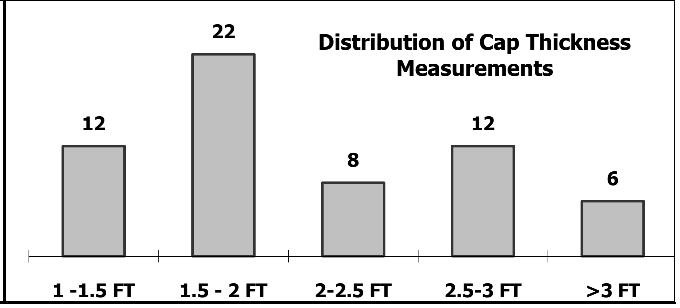
Bathymetric surveys were conducted before and after the cap material were placed. The purpose of these surveys was to collect data on gravel layer thickness by comparing the pre- and post-capping surfaces. The bathymetric surveys did not work as intended, however, primarily due to the shallow water depths that resulted from the placement of so much gravel. The excess gravel was believed to result from the requirement that the gravel be placed in two lifts.

In order to compensate for the loss of the bathymetric data, RMC manually collected thickness verification data. A total of 60 measurements were collected, 5 from each of the cells with >10 ppm PCBs. Measurements were not collected from the cells with <10 ppm PCBs; however, as the capping procedures for these cells were identical to the surrounding >10 ppm cells, there is no reason to believe that the as-built thickness of the gravel would be different. Table 3-24 presents the northings, eastings, and cap thickness for these 60 measurements. The measurements are plotted on Figure 3-39.

Table 3-24
Cap Thickness Verification Measurements

Location	Northing	Easting	Thickness (ft)	Location	Northing	Easting	Thickness (ft)
C41a	2,242,157.9	427,076.6	**2.0**	C27a	2,242,250.0	427,286.1	**3.0**
C41b	2,242,162.5	427,103.6	**1.1**	C27b	2,242,255.8	427,308.7	**1.5**
C41c	2,242,135.5	427,079.8	**3.0**	C27c	2,242,226.1	427,291.7	**1.5**
C41d	2,242,148.2	427,091.0	**2.0**	C27d	2,242,234.5	427,325.3	**3.0**
C41e	2,242,141.2	427,107.7	**1.6**	C27e	2,242,243.2	427,304.1	**2.5**
C42a	2,242,167.5	427,126.1	**1.6**	C86a	2,242,039.8	427,128.1	**1.8**
C42b	2,242,148.3	427,129.4	**2.0**	C86b	2,242,027.6	427,206.6	**1.0**
C42c	2,242,151.0	427,140.9	**1.2**	C86c	2,242,034.6	427,183.2	**1.0**
C42d	2,242,155.8	427,154.2	**2.0**	C86d	2,242,052.4	427,201.4	**3.4**
C42e	2,242,173.2	427,145.8	**1.6**	C86e	2,242,044.4	427,162.7	**2.0**
C43a	2,242,185.2	427,185.7	**1.0**	C76a	2,242,104.6	427,223.0	**2.5**
C43b	2,242,174.3	427,188.9	**1.5**	C76b	2,242,079.4	427,228.5	**3.0**
C43c	2,242,166.7	427,209.0	**2.0**	C76c	2,242,086.6	427,205.1	**2.5**
C43d	2,242,159.8	427,179.4	**2.0**	C76d	2,242,071.2	427,195.8	**6.9**
C43e	2,242,189.0	427,208.3	**1.0**	C76e	2,242,096.0	427,190.3	**1.3**
C44a	2,242,171.1	427,231.2	**2.0**	C77a	2,242,111.5	427,263.5	**2.2**
C44b	2,242,176.7	427,251.6	**3.0**	C77b	2,242,087.2	427,269.0	**4.0**
C44c	2,242,191.8	427,221.9	**3.0**	C77c	2,242,095.9	427,257.5	**3.6**
C44d	2,242,197.8	427,249.1	**2.6**	C77d	2,242,107.6	427,244.2	**3.0**
C44e	2,242,186.4	427,238.9	**2.0**	C77e	2,242,078.6	427,246.2	**3.2**
C45a	2,242,181.7	427,275.6	**1.5**	C78a	2,242,120.6	427,303.2	**3.0**
C45b	2,242,187.9	427,303.2	**2.1**	C78b	2,242,095.5	427,308.1	**3.4**
C45c	2,242,201.8	427,269.8	**1.8**	C78c	2,242,107.9	427,305.4	**3.0**
C45d	2,242,207.5	427,296.2	**1.0**	C78d	2,242,103.3	427,288.8	**2.1**
C45e	2,242,195.6	427,287.7	**2.5**	C78e	2,242,110.0	427,323.2	**2.2**
C46a	2,242,193.3	427,327.6	**2.0**	C65a	2,242,176.5	427,353.6	**2.7**
C46b	2,242,197.5	427,348.4	**2.0**	C65b	2,242,181.9	427,374.4	**2.0**
C46c	2,242,210.7	427,333.7	**2.0**	C65c	2,242,166.2	427,369.8	**3.0**
C46d	2,242,213.9	427,320.7	**1.8**	C65d	2,242,151.9	427,360.2	**2.0**
C46e	2,242,218.2	427,345.6	**2.0**	C65e	2,242,159.3	427,385.7	**2.0**

Summary statistics:
Number of measurements: 60
Range of measured thicknesses: 1.0 – 6.9 ft
Average thickness: 2.3 ft



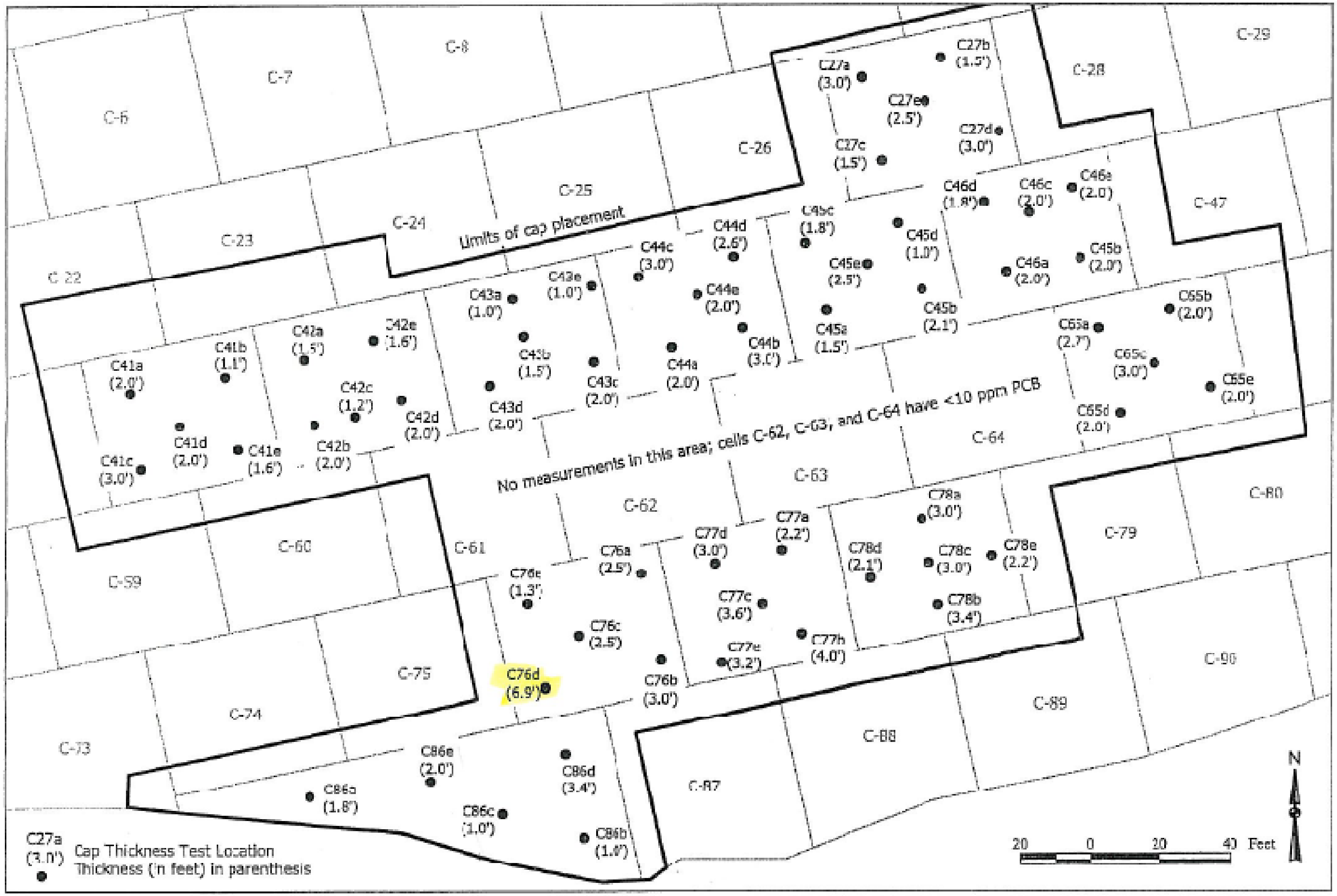


Figure 3-39
Cap Thickness Measurements

4.0 ENVIRONMENTAL MONITORING RESULTS

The *Environmental Monitoring Plan* (EMP) in the *Remedial Action Work Plan* (Bechtel 2001) presented the scope, rational and procedures for monitoring environmental conditions in areas potentially impacted by the sediment remediation activities. These potential impacts include:

- Unanticipated release of resuspended PCB-contaminated sediments from the area enclosed by the sheet pile wall into the river water column.
- Ineffectiveness of the water treatment plant to adequately remove PCBs, suspended solids, and oil and grease from treated water.
- Unanticipated release of PCBs associated with airborne particulates during handling, storage or transport of dredged sediments.

The scope of the monitoring program increased during remedial construction activities, primarily in response to concerns from EPA regarding the potential for additional impacts from the remediation (e.g., dissolved-phase PCBs, PAHs and PCDFs within the sheet pile enclosure) or in response to DEC requirements (e.g., expanded effluent monitoring for the water treatment plant). This increased scope had a tremendous impact on both the complexity and cost of the remediation, as hundreds of additional samples were collected that had to be tracked, recorded, evaluated, and reported.

In the following sections, the results of the various monitoring activities will be presented in a summary fashion. In the vast majority of cases, the monitoring resulted in either non-detect results or detectable results below the EMP action levels. Expanded discussion will focus on any portion of the monitoring where there was an exceedance of an action level or other causes for concern.

4.1 MONITORING IN THE ST. LAWRENCE RIVER

Monitoring activities conducted in the St. Lawrence River included the following:

- Monitoring river water column turbidity as an indicator of total suspended solids (TSS) at designated stations up current and down current of sheet pile installation, dredging operations, and sheet pile removal (monitoring locations were adjusted as dredging operations proceeded).

- Monitoring for PCBs, PAHs and PCDFs in river water at the up current and down current turbidity monitoring stations

- Monitoring of water quality within the sheet pile enclosure to determine whether dissolved-phase PCBs, PAHS and PCDFs are present in the water column.

Turbidity measurements and surface water samples were collected in the St. Lawrence River to identify any impacts on water quality associated with the disturbance or release of contaminated sediments during the remediation activities.

Previous studies identified areas of water movement in an upstream (westerly) direction in the Reynolds Study Area, therefore the terms “up current” and “down current” have been used to accurately reflect the direction of water movement instead of the more common terms “upstream” and “downstream.” Turbidity measurements and water column samples were collected from monitoring points up current and down current of the sheet pile installation or dredging operations. In addition, a fixed background station was used that was upstream—and up current—of the remediation area. The up current and down current monitoring locations were determined in the field on the basis of observed river current flow patterns.

Additional current velocity and direction studies were conducted during the remediation activities to verify proper placement of monitoring points during installation of the sheet pile wall and dredging operations. An initial, preliminary current study, conducted prior to completion of the sheet pile wall, was used to verify the placement of monitoring points relative to the construction activities. A follow-on current study was conducted after the sheet pile wall was completed. This study followed the same approach and procedures used in the 1995 *Velocity and Wave Height Study* (ATL 1995). Its results were used to guide the selection of monitoring locations during dredging operations.

4.1.1 Turbidity Monitoring

Turbidity measurements were collected using a direct-reading turbidimeter (Hydrolab) that was calibrated each day in accordance with the manufacturer's specifications. In addition, QC checks of the Hydrolab were conducted using a Hach turbidity measuring kit. The frequency of Hach kits varied but averaged at least one check per station per day.

Turbidity data were also collected with a data-logging turbidimeter, which was installed at a fixed location and recorded turbidity measurements according to a defined schedule (e.g., once a minute or once every 60 minutes). All turbidity monitoring results are presented in Appendix D.

4.1.1.1 Turbidity Monitoring During Sheet Pile Installation

Turbidity was monitored at 3 separate points relative to each derrick barge engaged in sheet pile installation. These points included a location 100 ft up current of the active location, and two down current monitoring points at distances of 200 and 400 ft. A fixed background monitoring location was also established approximately 100 ft upstream and up current from the western-most point of sheet pile installation as shown in Figure 4-1. Turbidity monitoring stations were adjusted as the construction progressed on the wall. A typical monitoring configuration during sheet pile installation is shown in Figure 4-2.

The turbidity monitoring locations were identified relative to the operating pile installation barges. The turbidity measurements were taken at two-hour intervals, and also if any visible release of sediment was observed during sheet pile installation (this happened a few times, due to bottom disturbances from tugboat activity). The measurements were taken at approximately 50% of river depth starting within 30 minutes of any sediment disturbance and ending about 30 minutes after the work shift or activity involving sediment disturbance had been completed.

A total of 1,780 turbidity measurements were collected during the 51 days of sheet pile installation (Table 4-1), which is an average of about 35 measurements per day. Different numbers of measurements were collected at each station because of overlap in monitoring stations, equipment downtime, and other factors.

Out of the total of 1,780 routine turbidity measurements (every 2 hours at from 4 to 10 locations), there were only 10 detections of turbidity with the Hydrolab during sheet pile installation. Hach data collected as a QC check on the Hydrolab consistently measured detectable turbidity at levels that averaged 0.5 to 1.5 NTUs. Discussions with the turbidity meter manufacturer (Hydrolab) indicated that an error of 2.6% could be expected when the turbidimeter was calibrated from 0 to 100 NTU, which is the vendor's suggested range. Based on this, a reading of 0.0 could be as high as 2.6 NTU, and 2.6 NTU is effectively the detection limit for the instrument. This detection limit demonstrated perfect correlation with the Hach turbidimeter confirmation measurements that were collected throughout the turbidity-monitoring program.

Table 4-1
Summary of Turbidity Measurements During Sheet Pile Installation

			Number of Turbidity Measurements			
	Start Date	**End Date**	**100 ft Up current**	**200 ft Downcurrent**	**400 ft Downcurrent**	**Other**
Comanche	4/13/01	6/12/01	203	199	159	
Ryba IV-Spot	4/19/01	6/4/01	106	139	112	
Cat 350	4/17/01	6/7/01	202	196	185	
On-shore	5/23/01	5/23/01	3	3	3	
Fixed Background	4/13/01	6/1201				270
Totals	*4/13/01*	*6/12/01*	*514*	*537*	*459*	*270*

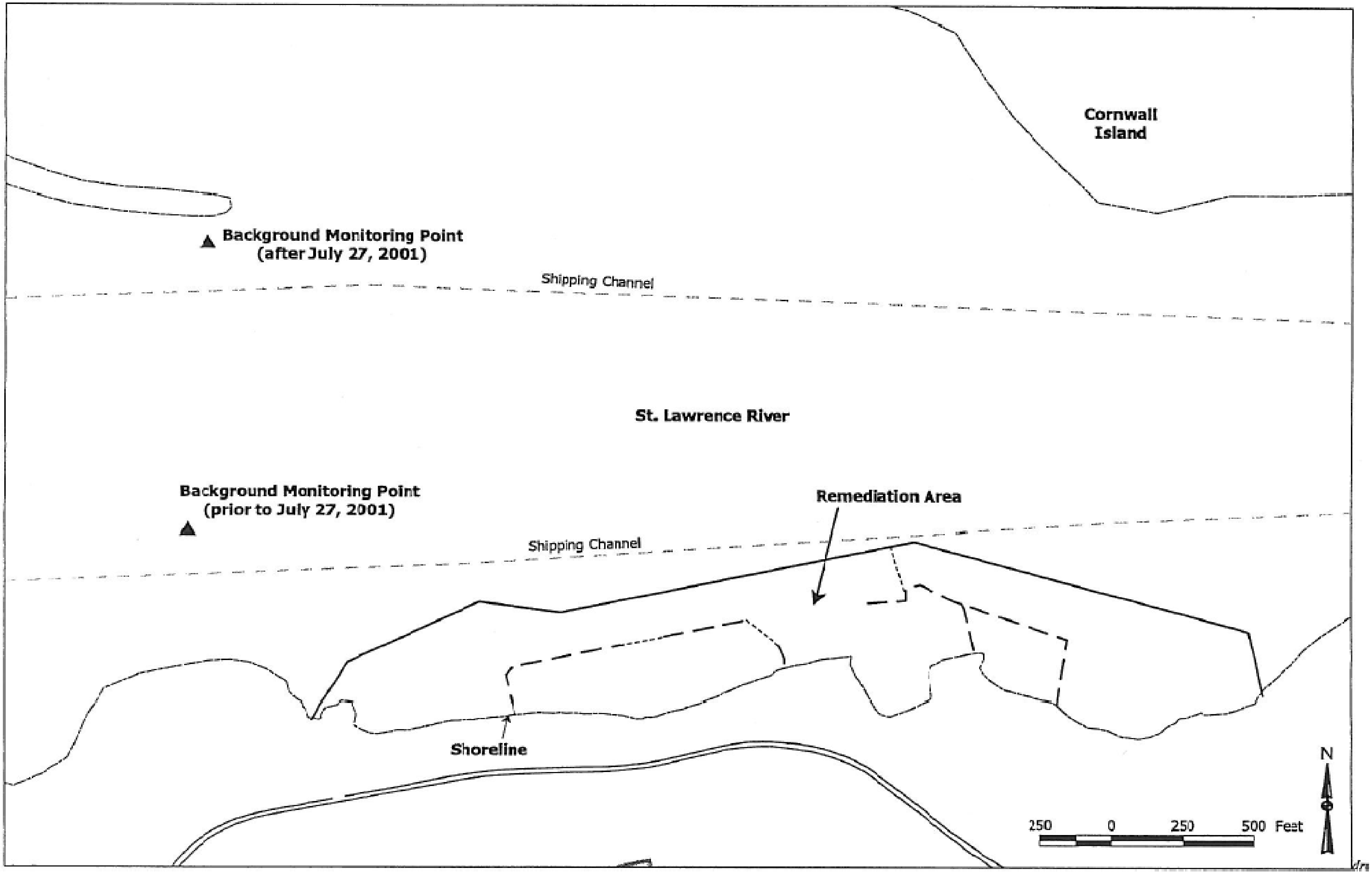


Figure 4-1
Fixed Background Sample Location

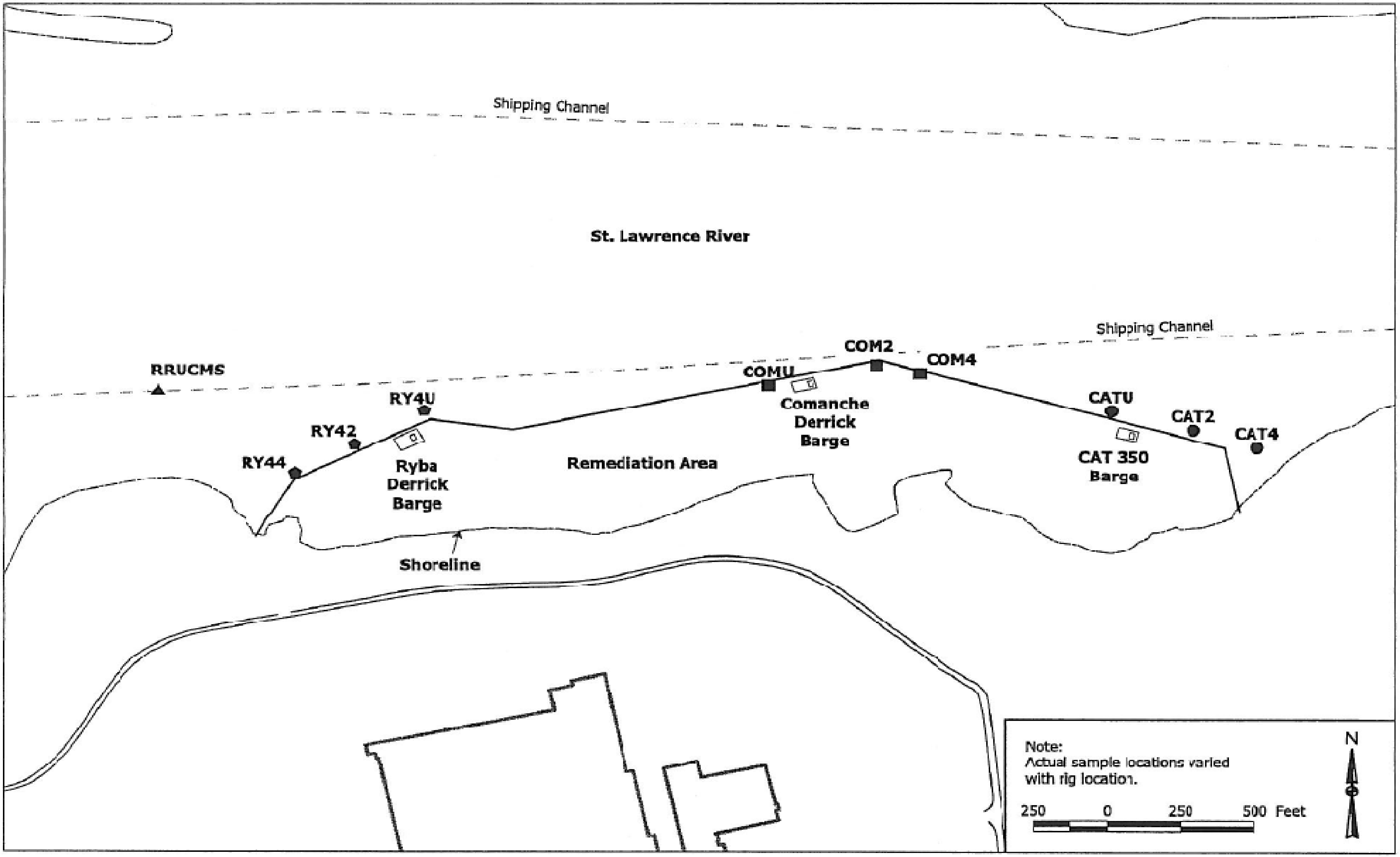


Figure 4-2
Monitoring Configuration for Sheet Pile Installation (Typical)

There were several incidents where visible turbidity was noted during barge movement, and in nearly all of these cases, both Hydrolab and Hach kit turbidity measurements were collected (Hach kit measurements were collected whenever a water sample was collected). With the exception of these isolated incidents, all routine Hydrolab detections were below the action level, averaging 2.8 NTUs.

Because of the large number of non-detect readings collected with the Hydrolab and the obvious need to verify the accuracy of the data, an evaluation of the QC verification data collected using the Hach kit is warranted; this evaluation is presented below.

The 270 Hydrolab turbidity readings collected at the fixed background station during sheet pile installation were all recorded as non-detect (ND). A total of 79 Hach kit turbidity measurements were collected, equal to a QC verification rate of nearly 30 percent. The Hach results ranged from 0.46 to 2.15 NTUs, with an average of 1.01 NTUs. Figure 4-3 shows how the turbidity varied over time at the up current/background station, during which time all Hydrolab readings were ND. Although the Hydrolab could not quantify turbidity in the 0.5 – 2 NTU range, these values are well below the level of concern for the project. Regular use of the Hach kits for QC verification purposes confirmed visual observations that the river water was essentially free of turbidity.

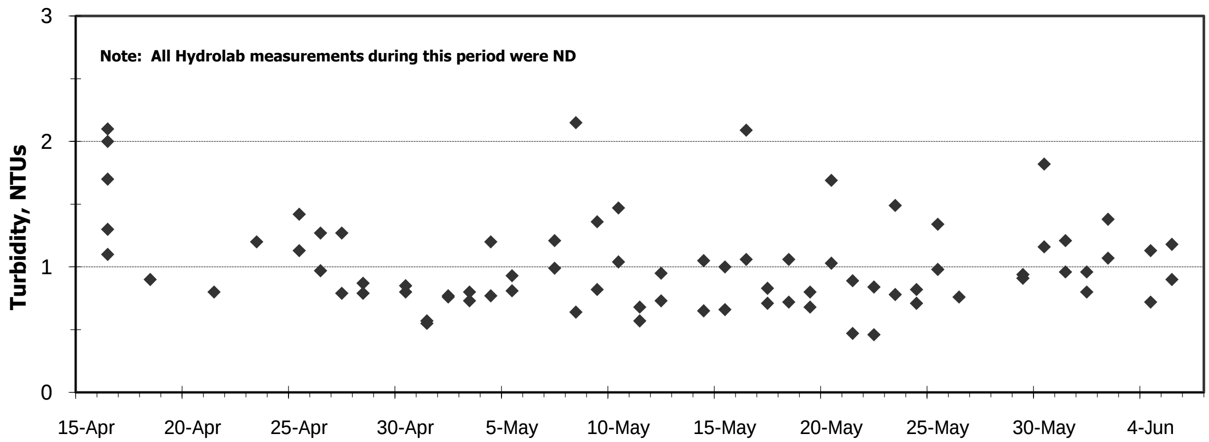


Figure 4-3
Hach Turbidity at Background Station During Sheet Pile Installation

An additional evaluation of Hach kit turbidity data was completed for the 100 ft up current and 200 ft down current station associated with the Cat 350 during sheet pile installation (Figure 4-4). For the 200 ft down current station, there were 67 measurements with the Hach kit, equivalent to a 34% QC verification rate. For the 100 ft up current stations, there were72 measurements (36% QC verification rate).

The Hach data shown on Figure 4-4 includes routine measurements only and no data collected in response to visible turbidity in the water (these data are presented below). As far as routine measurements were concerned, the Hydrolab was providing mostly ND readings, which correlate to the vast majority of Hach data that were below 2 NTUs. The Hydrolab was able to quantify higher levels of turbidity, as shown in the turbidity data tables presented in Appendix D, but again was unable to resolve low levels of turbidity (1-2 NTUs). Given that action levels were set at 25 NTUs above background, this limitation was not identified as a concern during the project.

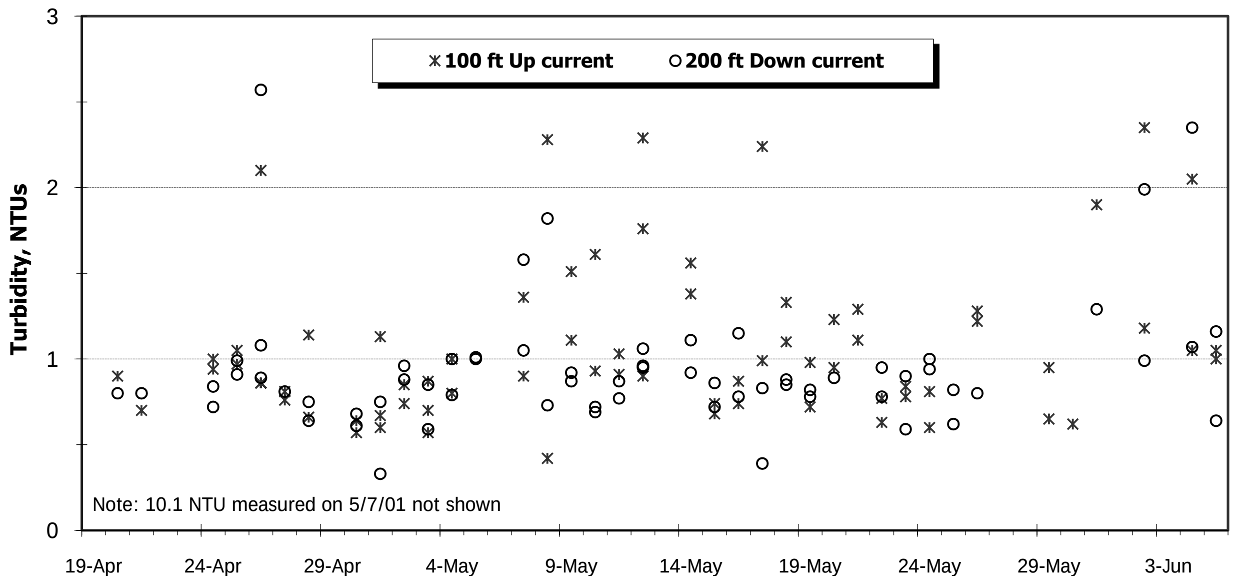


Figure 4-4
Hach Turbidity at Cat 350 During Sheet Pile Installation

There was only one exceedance of the turbidity action level (25 NTUs over background) during sheet pile installation. This exceedance occurred on May 10, 2001, at 7:50 am. The measurement was collected from the up current monitoring station for the Comanche derrick barge and was taken approximately 5 minutes after the barge had been moved with a tugboat.

Elevated turbidity was occasionally observed around the barges and tugboats, particularly when operations were in relatively shallow water (8 ft or less); in these cases, the monitoring team moved into the turbid water to monitor levels and collect water column samples for PCB analysis. If the levels had not dissipated quickly, the work activities would have been temporarily suspended. A summary of the incidents associated with visible turbidity and the response actions taken (measurements, sampling) is shown in Table 4-2.

Table 4-2
Observed Turbidity Plumes and Response During Sheet Pile Installation

Date	Time	Depth (ft)	Turbidity NTU	Log Sheet Comment	Sampled?	PCB Results
200 ft Down current from Cat 350 Derrick Barge (CAT2)						
4/20/01	13:59	3.5	23	Turbidity cloud from tug but dropped off quickly	No	--
Adjacent to Cat 350 Derrick Barge						
5/7/01	18:25	8	17.1	Collected PCB sample adjacent to CAT 350	Yes*	ND
5/8/01	11:05	7.5	22.7	Collected sample at CAT 350 barge	Yes	ND
5/8/01	13:20	6.5	25.1	Collected sample at CAT 350 barge	Yes	ND
5/8/01	13:35	6.5	13.1	Collected sample at CAT 350 barge	Yes	ND

Date	Time	Depth (ft)	Turbidity NTU	Log Sheet Comment	Sampled?	PCB Results
100 ft up current from Cat 350 Derrick Barge (CATU)						
5/16/01	14:35	9.5	5.2	Rochell Kay tug moving barge in area	No	--
100 ft up current from Comanche Derrick Barge (COMU)						
5/7/01	8:19	4	6.3	Lyndhurst tug creating visible turbidity	No	--
5/10/01	7:50	5	31.0 27.5	Measurement taken approximately 5 minutes after tug moved barge	Yes	ND
5/16/01	14:10	6.5	20.9	Lyndhurst tug at Comanche barge creating turbidity cloud	Yes	ND

Note: Detection limits for PCB analyses reported at 0.065 µg/L
* Both filtered and unfiltered samples were collected on 5/7/01; both results ND

All samples collected in association with turbidity plumes had non-detectable results for PCBs. In all cases, the effects were localized and the turbidity dissipated quickly (typically in less than a minute).

4.1.1.2 Turbidity Monitoring During Dredging

Water quality in the St. Lawrence River was closely monitored during dredging operations. Up current and down current monitoring stations were established for turbidity measurements and water column sampling. Monitoring locations were selected on the basis of the current velocity and direction study that was completed after construction of the sheet pile wall.

Background turbidity data was collected from a fixed background station located northwest of the sheet pile enclosure; its precise location was identified on the basis of the current study. Background data was also collected from stations 100 ft up current from each active dredge; these stations moved as the dredging progressed. Down current monitoring during dredging utilized three locations at distances of 10, 150, and 300 ft (Table 6-2). The nearest (10 ft) down current location was positioned at the point on the sheet pile wall closest to the dredge being monitored (in a down current direction), and the 150 and 300 ft stations were be down current from that point. All three of the down current monitoring stations were also moved as the dredging progressed. Figure 4-5 presents a typical monitoring configuration used during dredging activities.

Turbidity measurements were obtained using a direct-read turbidimeter. The measurements were taken at 2-hour intervals starting just prior to dredging operations and ending with the completion of work each day. During the first 2½ weeks of dredging (June 12 – June 29, 2001), turbidity measurements were taken at 20%, 50%, and 80% of water depth to determine the optimum depth for measurements to be taken for the balance of the dredging operations. These measurements did not identify an appreciable vertical profile in the turbidity, and after the 29th of June all measurements (and sampling) were taken at 50% of the river depth. The turbidity monitoring team periodically collected additional measurements at the 20%, 50% and 80% depths to confirm the absence of vertical turbidity contrasts; no such contrasts were observed.

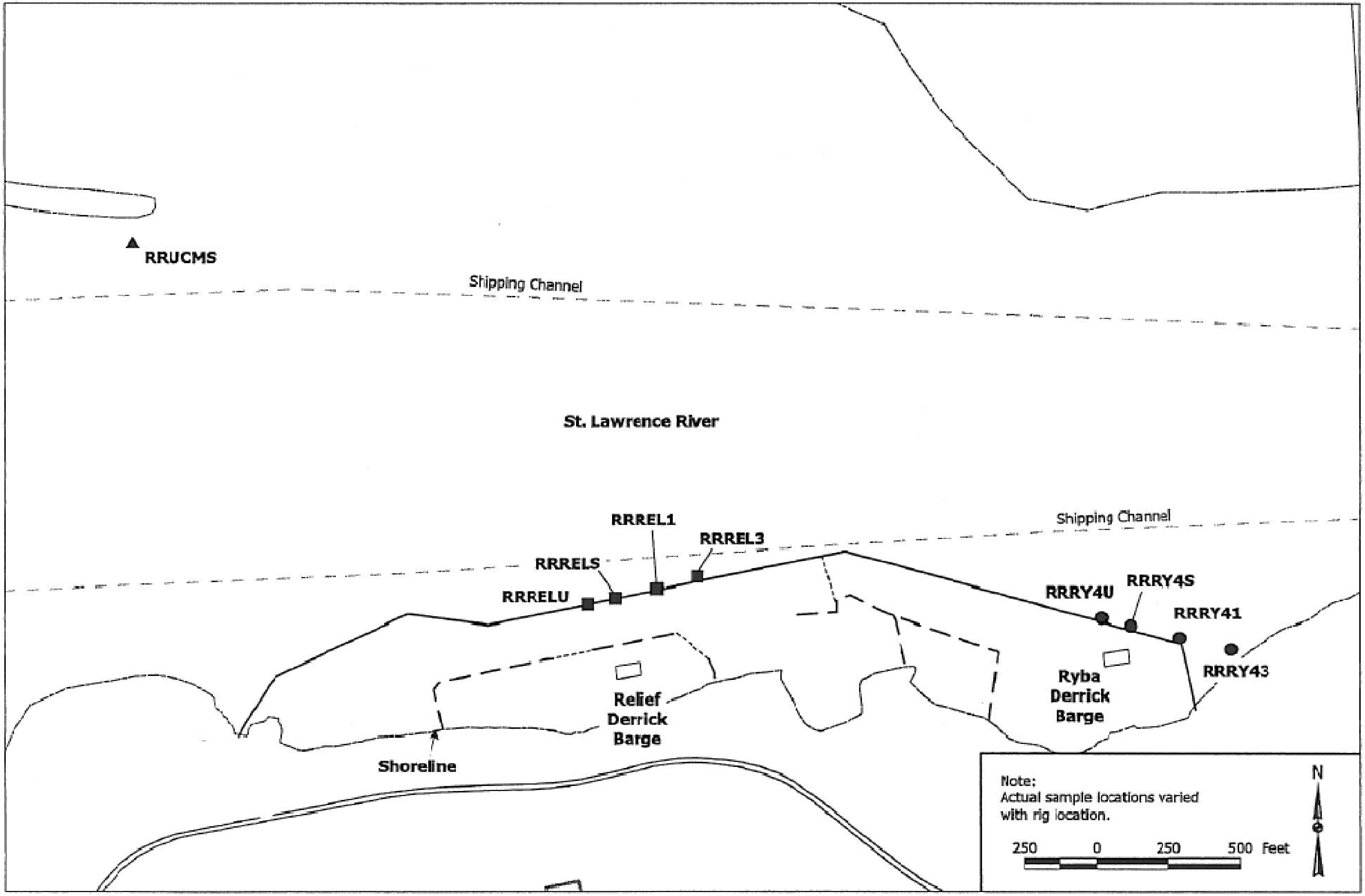


Figure 4-5
Monitoring Configuration for Dredging (Typical)

Dredging operations were active for 107 days (June 12 – October 16, 2001). During this time, a total of 5,327 turbidity measurements were collected, which equates to an average of about 50 measurements per day during dredging operations. Table 4-3 provides a breakdown of turbidity measurements collected for each of the derrick barges and the fixed background location during dredging operations.

Table 4-3
Summary of Turbidity Measurements During Dredging

			Up current Measurements		Down current Measurements		
Derrick or Location	Start	**End**	**Backgrnd**	**100 ft**	**10 ft**	**150 ft**	**300 ft**
Comanche	6/28/01	10/16/01	--	260	284	265	237
Cat 350	6/23/01	10/18/01	--	76	78	68	66
Ryba IV-Spot	6/15/01	10/16/01	--	326	338	319	302
Relief	6/12/01	10/17/01	--	462	470	447	431
Background	6/12/01	10/18/01	898	--	--	--	--
Total Measurements	*4/13/01*	*6/12/01*	*898*	*1,124*	*1,170*	*1,099*	*1,036*

No significant turbidity was observed during any of the river monitoring activities during dredging. The Hydrolab measurements were mostly non-detect, while those from the Hach kit were typically in the range of 0.5 to 1.5 NTUs. Table 4-4 summarizes the range of detected turbidity for each derrick and station. Examination of the Hach turbidity completed as QC verification for the Hydrolab shows a similar trend to that observed during installation of the sheet pile wall: the Hydrolab reported non-detectable turbidity only at the lowest end of the scale (<2 NTUs), which was quantifiable with the Hach kit. There was no evidence that the Hydrolab had any problems identifying turbidity that may be of a concern. Overall, there was no appreciable turbidity to measure in the St. Lawrence River.

Table 4-4
Measured Turbidity in the St. Lawrence River During Dredging

	Measured Turbidity (NTUs)									
	Fixed Background		100 ft Up current		10 ft Down current		150 ft Down current		300 ft Down current	
Location	*Range*	*Avg*	*Range*	*Avg*	*Range*	*Avg*	*Range*	*Avg*	*Range*	*Avg*
Comanche			0.6 - 3.4	1.5	0.6 - 4.6	1.3	0.5 - 3.1	1.3	0.4 - 1.9	1.1
Cat 350			0.6 - 2.7	1.2	0.4 - 2.2	1.1	0.4 - 3.1	1.2	0.3-2.2	1.1
Ryba IV-Spot			0.5 - 3.0	1.3	0.2 - 3.5	1.4	0.3 - 3.6	1.2	0.5-3.3	1.2
Relief			0.6-10.8	2.1	0.5 - 8.4	1.8	0.5 - 14.1	1.8	0.7-6.0	1.8
Background	0.4 - 9.5	1.5								

Note: Measured turbidity reflects both Hydrolab and Hach kit measurements.

The absence of measurable turbidity in the river is due to the successful performance of the sheet pile wall in containing the suspended sediment generated from the dredging activities. Dredging did generate turbidity, as will be seen in the following section. The contrast between turbidity levels inside the sheet pile wall and those in the St. Lawrence River provide additional support to the conclusion that the sheet pile wall was functioning properly.

4.1.1.3 Turbidity Monitoring During Capping

Capping operations were conducted October 26 – November 2, 2001 (8 days). During this time, turbidity was measured at five stations, all of them inside the sheet pile enclosure. The stations included a background station, 100 ft up current station, a station adjacent to the Cat 350 (the derrick used for placement of the capping materials), and down current stations at 150 ft and 300 ft from the capping operation. Measurements were collected using the same procedures and schedule utilized for monitoring during dredging operations. Table 4-5 summarizes the turbidity measurements collected during capping.

Table 4-5
Turbidity Measurements Inside Sheet Pile Wall During Capping

	Background	100 ft Up current	Adjacent to Barge	150 ft Down current	300 ft Down current
Duration	10/31/01 - 11/2/01	10/26/01 – 11/2/01			
No. Measurements	10	29	30	31	31
Range	9.6 - 19.3	10.1 - 93.2	7 - 109.1	11.5 - 96.4	0.9 - 72.3
Average	13.2	49.4	51.7	42.9	36.1

Note: All measurements collected from within sheet pile enclosure; Background station at 33+00 on wall

Turbidity levels measured during capping were comparable to those observed inside the wall during dredging operations. No monitoring was conducted in the St. Lawrence River (i.e., outside the sheet pile wall) during capping. Given the significant database of evidence that the sheet pile was functioning as designed during dredging operations (i.e., the 5,327 turbidity measurements collected from the St. Lawrence River during dredging operations that showed no impact on the river), it was assumed that the capping operations likewise had no measurable effect on water quality in the St. Lawrence River.

4.1.1.4 Turbidity Monitoring During Sheet Pile Removal

Turbidity monitoring during removal of the sheet pile wall was originally expected to mirror that conducted for installation of the wall. Due to concerns regarding the release of water from within the sheet pile enclosure, however, RMC completed a large amount of additional water quality monitoring as a prelude to opening up the wall; this additional monitoring will be discussed in detail in the following sections that address water sampling. RMC also agreed, in response to a request from the St. Regis Mohawk Tribe, to lower the turbidity action level in the St. Lawrence River from 25 to 10 NTUs. The 10 NTU action level was used for monitoring the 3 openings created as a prelude to the removal of the entire wall, as well during removal of the wall.

Removal of the sheet pile wall proceeded in phases. Three 100-ft openings were created and water quality was closely monitored in the river to verify no impact from the release of the formerly enclosed water. Once it was determined that there was no impact on water quality in the river due to the release of this water, EPA allowed RMC to proceed with removal of the balance of the wall.

A total of 1,451 turbidity measurements were collected during the 18 days of sheet pile wall removal activities. This total equates to an average of 80 turbidity measurements per day while the steel was being pulled, more than at any other time during the remediation activities. Table 4- 6 summarizes the scope of turbidity monitoring completed for the initial openings and wall removal activities.

Table 4-6
Summary of Turbidity Measurements During Removal of Sheet Pile Wall

			Number of Turbidity Measurements		
	Start Date	**End Date**	**100 ft Up current**	**200 ft Down current**	**400 ft Down current**
East Opening	11/8/01	11/14/01	99	102	102
West Opening	11/10/01	11/14/01	78	78	60
Center Opening	11/14/01	11/14/01	12	12	12
Relief	11/6/01	11/23/01	78	156	74
Comanche	11/7/01	11/8/01	2	2	1
Ryba IV-Spot	11/8/01	11/16/01	85	95	84
Cat 350	11/9/01	11/25/01	97	154	68
Totals	*11/6/01*	*11/25/01*	*451*	*599*	*401*

Turbidity data during removal of the sheet pile wall is summarized in Table 4-7. The majority of the measurements during this phase of the monitoring program were collected using the Hach kit. Turbidity levels in the river were comparable to those observed during earlier phases of the work, and were predominantly in the range of 1-2 NTUs. Even with the lowered action level of 10 NTUs, there were no exceedances identified during any part of the wall removal activities.

Table 4-7
Measured Turbidity in the St. Lawrence River During Removal of Sheet Pile Wall

	Measured Turbidity (NTUs)					
	100 ft Up current		**200 ft Down current**		**400 ft Down current**	
Location	*Range*	*Avg*	*Range*	*Avg*	*Range*	*Avg*
East Opening	0.5 - 3.5	1.7	0.7 - 9.5	2.2	0.7 - 3.2	1.6
West Opening	0.8 - 6.2	2.4	0.8 - 4.4	2.1	0.8 - 4.5	1.9
Center Opening	0.5 - 1.0	0.7	0.5 - 1.3	0.8	0.7 - 1.4	1.0
Relief	0.8 - 5.0	1.7	0.5 - 3.3	1.5	0.6 - 2.6	1.6
Comanche	ND	--	1.62	--	ND	--
Ryba IV-Spot	0.8 - 6.7	1.9	0.7 - 3.7	1.8	0.8 - 6.0	1.7
Cat 350	0.5 - 5.9	2.0	0.4 - 7.0	1.9	0.5 - 9.5	1.8

Note: Action Level was 10 NTUs during removal of sheet pile wall

4.1.1.5 Overview of Turbidity Measurements

Turbidity data provide an excellent metric for evaluation of the effectiveness of the containment systems used to minimize impacts on the St. Lawrence River during the 2001 remedial action. A total of 8,558 turbidity measurements were collected in the St. Lawrence River during construction of the sheet pile wall, dredging, and removal of the wall. This comprehensive monitoring effort and resulting database showed that the remediation activities had little or no impact on water quality in the St. Lawrence River. The containment systems performed as designed in isolating the remediation activities and preventing releases of contaminated sediment to the river.

Figure 4-6 presents a comparison of the minimum, maximum and average turbidity measured in the water column of the St. Lawrence River during the installation and removal of the sheet pile wall and during dredging operations (data from the sheet pile installation are based on the Hach QC data and measurements associated with turbidity plumes as described earlier). Measurements collected during capping were excluded because these measurements were collected inside the sheet pile.

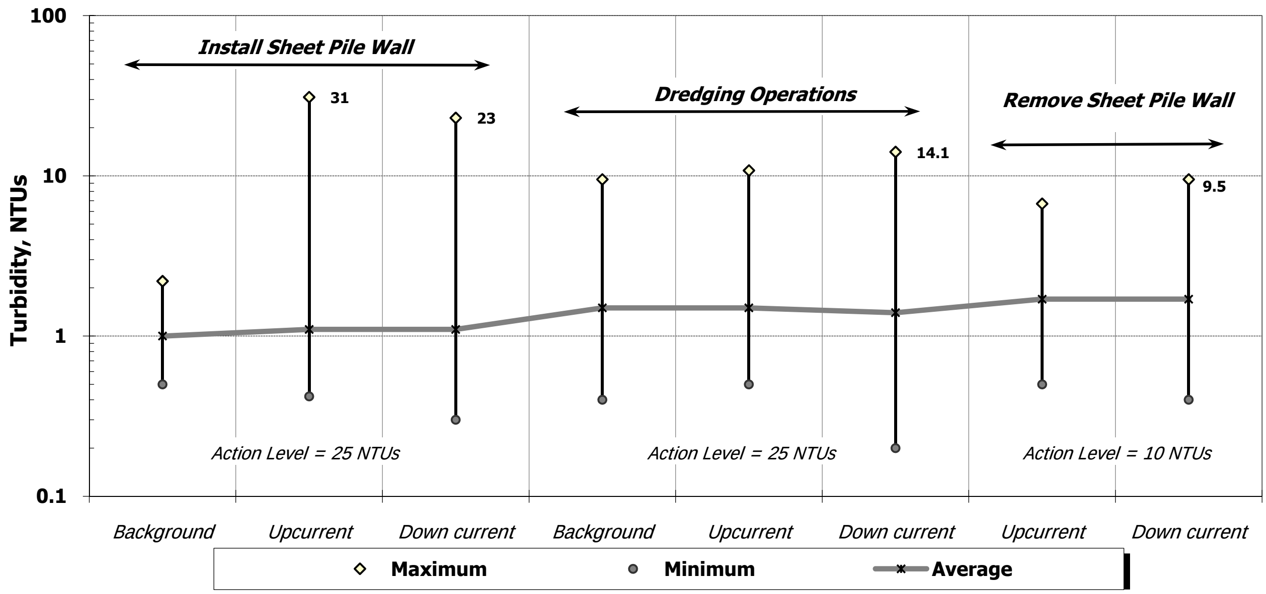


Figure 4-6
Comparison of Measured Turbidity During the Remedial Action

The comparison chart shows that even with the isolated, barge-movement related upsets that occurred during sheet pile installation, average turbidity values were relatively constant, varying mostly between 1 and 2 NTUs at all stations throughout the remedial action activities. Given the correlation between suspended solids and contamination levels in the water column (examined in greater detail below), the absence of turbidity in the water column of the river, based on over 8,000 measurements collected at rates of 35 to 80 measurements per day, supports the conclusion that the remediation had no impact on water quality in the St. Lawrence River.

4.1.2 Water Column Sampling

Water quality samples were collected from monitoring stations established in the St. Lawrence River throughout the remediation activities. The objective of this sampling activity was to identify any impacts on water quality associated with the disturbance or release of contaminated sediment during the installation or removal of the sheet pile wall, dredging, or capping activities. Results from the sampling activities are discussed below.

4.1.2.1 Water Column Monitoring During Sheet Pile Installation

During sheet pile installation activities, water samples were collected from the St. Lawrence River at a down current turbidity monitoring point (typically 200 ft down current) and from an up current station (100 ft up current station). The samples were collected from the same depth used for measurement of turbidity (50% of river depth) and analyzed for PCBs. Samples were also collected whenever visible or elevated turbidity readings were observed. The action level for water quality samples during sheet pile installation was 2 µg/L of PCBs.

Discrete depth surface water samples were collected in accordance with procedure REP-007. The method involved the use of a bottle sampler connected to a cable equipped with a weighted messenger. The spring-loaded end seals on the bottle were set to the open position before lowering the sampler into the water. The sampler was lowered to the desired sampling depth and the weighted messenger dropped down to activate the spring-loaded end seals of the bottle. Once the sampler was retrieved, the water was then transferred to the appropriate sample containers. Turbidity was also measured using the Hach kit.

A total of 111 water samples were collected during sheet pile installation activities. Sampling details are provided in Table 4-8. All of the samples were analyzed for PCBs and all results were reported as non-detect at a detection limit of 0.065 µg/L. Sample results are presented in Appendix D.

Table 4-8
Water Column Sampling During Sheet Pile Installation

			Number of Water Quality Samples		
	Start	**End**	**100 ft Up current**	**200 ft Down current**	**Other**
Cat 350	4/23/01	6/5/01	32	32	
Comanche	5/10/01	6/4/01	14	13	
Ryba IV Spot	4/19/01	5/25/01	5	4	
Fixed Background	4/23/01	4/24/01			4
Opportunity Sampling	5/7/01	5/16/01			7
Total Sampling	*4/19/01*	*6/5/01*	*51*	*49*	*11*

Note: Opportunity sampling conducted in response to visible or elevated turbidity readings during monitoring.

4.1.2.2 Water Column Monitoring During Dredging

Water column samples were collected daily from the St. Lawrence River outside the sheet pile enclosure during dredging at the 100 ft up current and three down current locations used for turbidity monitoring. Samples were collected at 50% of river depth at the monitoring point, which was also used for turbidity measurements. During the first week of dredging, while turbidity profiles were being collected to identify the optimal measurement and sampling depth, the water column samples were collected from the depth with the highest turbidity reading during the sample collection run.

Routine (daily) water samples were collected by the turbidity monitoring team. The samples were generally collected during the monitoring run scheduled 6 hours after the start of the first dredging shift. The actual timing varied depending on field conditions, the number of samples and types of analyses, etc.

During the first 3 weeks of environmental (as opposed to navigational) dredging, the samples were analyzed for PCBs, PAHs, and PCDFs as shown on Table 6-3. PAHs and furans were not detected during this initial period of sampling, and thus the analysis for these parameters was discontinued.

PCBs

A total of 661 unfiltered water column samples were collected for PCB analyses during dredging operations. Sampling details are shown in Table 4-9. The list includes several stations that were sampled only one time (e.g., RRCOM0 and RRRY42); these stations were sampled in response to specific field conditions such as rig location or accessibility. All other samples were collected at the stations identified above.

Table 4-9
PCB Sampling in the St. Lawrence River During Dredging

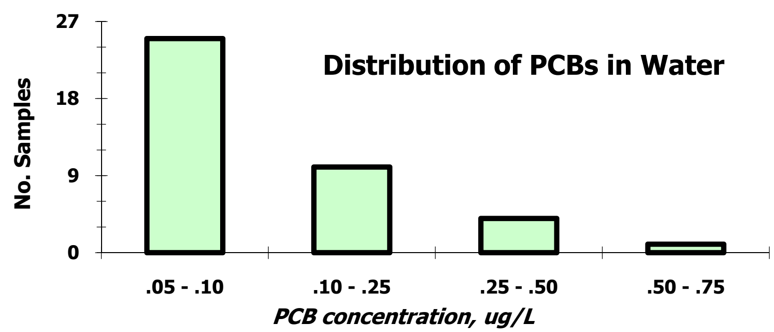
Derrick or Location	Station	Start	End	No. Samples	Detects	Action Level Exceedances
CAT 350	RRCAT1	6/27/01	10/13/01	15	2	0
	RRCAT3	6/27/01	10/15/01	10	1	0
	RRCATS	6/27/01	10/15/01	11	0	0
	RRCATU	6/27/01	10/15/01	10	0	0
COMANCHE	RRCOM0	6/28/01	6/28/01	1	0	0
	RRCOM1	6/28/01	10/12/01	61	3	0
	RRCOM3	6/28/01	10/12/01	44	3	0
	RRCOMS	6/28/01	10/12/01	56	2	0
	RRCOMU	6/28/01	10/12/01	49	1	0
RELIEF	RRREL1	6/16/01	10/6/01	57	7	0
	RRREL3	6/16/01	10/6/01	48	2	0
	RRRELS	6/16/01	10/6/01	61	2	0
	RRRELU	6/16/01	10/6/01	50	3	0
IV SPOT	RRRY41	6/15/01	10/8/01	48	4	0
	RRRY42	6/15/01	10/8/01	1	0	0
	RRRY43	6/15/01	10/8/01	44	3	0
	RRRY4S	6/15/01	10/8/01	49	5	0
	RRRY4U	6/15/01	10/8/01	45	2	0
Background	RRUCMS	8/18/01	8/18/01	1	0	0
Total Water Sampling		*6/15/01*	*10/15/01*	*661*	*40*	*0*

Detectable levels of PCBs were reported in 40 of these samples (including field duplicate results), in concentrations ranging from 0.05 to 0.53 µg/L. All reported detections were well below the action level of 2 µg/L. These detections are summarized in Table 4-10 and plotted in Figure 4-7.

Table 4-10
Detected PCBs in Water Column Samples from St. Lawrence River During Dredging

Derrick Barge	Station	Date	Total PCBs
RYBA IV SPOT	RRRY4U	14-Sep-01	0.53
	RRRY4S	26-Jul-01	0.087
	RRRY4S	14-Sep-01	0.33
	RRRY4S	19-Sep-01	0.23
	RRRY4S	20-Sep-01	0.06
	RRRY4S	08-Oct-01	0.076
	RRRY41	14-Sep-01	0.11
	RRRY41 (*dup*)	14-Sep-01	0.28
	RRRY41	20-Sep-01	0.07
	RRRY41	28-Sep-01	0.06
	RRRY43	14-Sep-01	0.15
	RRRY43	19-Sep-01	0.09
	RRRY43 (*dup*)	19-Sep-01	0.08
	RRRY4U	20-Sep-01	0.1
COMANCHE	RRCOMU	10-Sep-01	0.08 J
	RRCOMS	15-Sep-01	0.28
	RRCOMS	02-Oct-01	0.101
	RRCOM1	31-Jul-01	0.067
	RRCOM1	10-Sep-01	0.09 J
	RRCOM1	15-Sep-01	0.24
	RRCOM3	08-Sep-01	0.06
	RRCOM3	10-Sep-01	0.05 J
	RRCOM3	04-Oct-01	0.096

Derrick Barge	Station	Date	Total PCBs
RELIEF	RRRELU	28-Aug-01	0.06
	RRRELU	25-Sep-01	0.09 J
	RRRELU	20-Sep-01	0.06
	RRRELS	07-Sep-01	0.08 J
	RRRELS	25-Sep-01	0.22 J
	RRREL1	07-Sep-01	0.17 J
	RRREL1 (*dup*)	07-Sep-01	0.46 J
	RRREL1	24-Sep-01	0.06 J
	RRREL1 (*dup*)	24-Sep-01	0.07 J
	RRREL1	25-Sep-01	0.08 J
	RRREL1	01-Oct-01	0.08
	RRREL1	06-Oct-01	0.16
	RRREL3	07-Sep-01	0.06
	RRREL3	25-Sep-01	0.09 J
CAT 350	RRCAT3	04-Aug-01	0.082
	RRCAT1	07-Aug-01	0.066
	RRCAT1	15-Oct-01	0.177



Note: All concentrations in µg/L

PCB Action Level = 2 µg/L

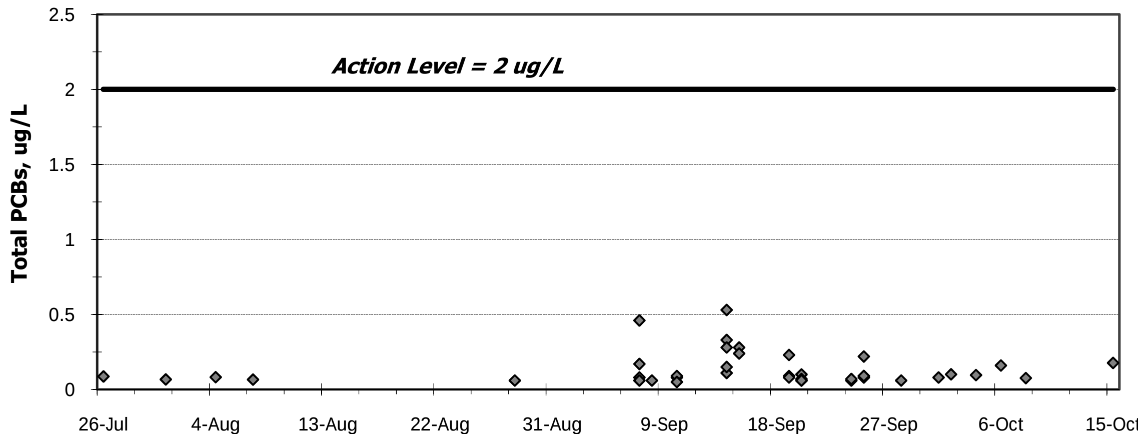


Figure 4-7
PCB Detections in St. Lawrence River Water Samples During Dredging

The majority of the detections (>60%) had less than 0.1 µg/L of PCBs. None of the samples had concentrations even close to the PCB action level in the river. The data also provide additional data that dredging did not result in the release of contamination during the remedial action

PAHs

A total of 59 unfiltered water column samples (including field duplicates) were collected for PAH analyses between June 19 and July 7, 2001. Table 4-11 identifies the sampling stations and number of samples collected at each location. PAH sampling results are presented in Appendix D.

Table 4-11
PAH Sampling in the St. Lawrence River During Dredging

Derrick	Station	Start	End	No. Samples	Detects	Action Level Exceedances
COMANCHE	RRCOM1	6/28/01	7/7/01	7	0	0
	RRCOM3	6/28/01	7/7/01	6	0	0
	RRCOMS	6/28/01	7/7/01	6	0	0
	RRCOMU	6/28/01	7/7/01	6	0	0
RELIEF	RRREL1	6/19/01	6/29/01	3	0	0
	RRREL3	6/19/01	6/29/01	3	0	0
	RRRELS	6/19/01	6/29/01	4	0	0
	RRRELU	6/19/01	6/29/01	3	0	0
IV SPOT	RRRY41	6/20/01	6/30/01	5	0	0
	RRRY43	6/20/01	6/30/01	5	0	0
	RRRY4S	6/20/01	6/30/01	6	0	0
	RRRY4U	6/20/01	6/30/01	5	0	0
Total PAH Samples		*6/19/01*	*7/7/01*	*59*	*0*	*0*

Note: Compound-specific PAH analyses were completed with detection limits of 0.2 µg/L

All PAH sample results were reported as non-detects (ND) from the lab. Sampling for PAHs was discontinued on the basis of these results. PAH analyses continued on samples collected on a weekly basis from inside the sheet pile enclosure; these sampling results are discussed later in this section.

PCDFs

A total of 50 unfiltered water column samples were collected for PCDF analyses between June 19 and July 5, 2001. Table 4-12 identifies sampling locations and the number of samples collected.

Table 4-12
PCDF Sampling in the St. Lawrence River During Dredging

Derrick	Station	Start	End	No. Samples	Detects	Action Level Exceedances
COMANCHE	RRCOM1	6/28/01	7/5/01	5	0	0
	RRCOM3	6/28/01	7/5/01	4	0	0
	RRCOMS	6/28/01	7/5/01	4	0	0
	RRCOMU	6/28/01	7/5/01	4	0	0
RELIEF	RRREL1	6/19/01	6/29/01	3	0	0
	RRREL3	6/19/01	6/29/01	3	0	0
	RRRELS	6/19/01	6/29/01	4	0	0
	RRRELU	6/19/01	6/29/01	3	0	0
IV SPOT	RRRY41	6/20/01	6/30/01	4	0	0
	RRRY43	6/20/01	6/30/01	5	0	0
	RRRY4S	6/20/01	6/30/01	6	0	0
	RRRY4U	6/20/01	6/30/01	5	0	0
	Total PCDF Samples	*6/19/01*	*7/5/01*	*50*	*0*	*0*

Note: AXYS reported detections for samples on June 25 and June 26, 2001 were later ruled invalid due to laboratory equipment problems

No furans were detected in any of the water column samples. Sampling for PCDFs was discontinued on the basis of these results. PCDF analyses continued on samples collected on a weekly basis from inside the sheet pile enclosure; these sampling results are also discussed later in this section.

4.1.2.3 Water Column Monitoring During Removal of Sheet Pile Wall

The scope of water sampling during removal of the sheet pile wall, as defined in the EPA-approved EMP, was intended to mirror that conducted during sheet pile installation: daily samples for PCB analyses, collected at the100 ft up current and 200 ft down current locations. In response to EPA concerns associated with the release of water from inside the enclosure, RMC undertook a greatly expanded monitoring effort involving additional turbidity measurements and water sampling. This effort included the collection of a large number of samples from inside the enclosure as a prelude to creating the three openings discussed earlier in the context of turbidity monitoring for sheet pile wall removal. A description of this activity is presented in Section 4.4.

Once the openings were created, samples were collected from locations upgradient and downgradient of the openings in the river. Preliminary results from these samples confirmed that the release of water from inside the enclosure had no measurable effect on water quality in the St. Lawrence River. Even so, as removal of the wall began, expanded water sampling continued, involving samples from both the interior ("SAM") locations within the sheet pile enclosure as well as samples from locations up current and down current from the rigs engaged in removal of the wall. EPA requested, and RMC agreed, to conduct expanded analyses for PAHs and PCDFs on the majority of these samples during all but the final few days of sheet pile removal activities.

Sampling associated with the east and west openings in the wall began on November 6 and continued through November 14. The initial samples collected in association with these openings were also tied to the derrick barges that were pulling the sheets to create the openings. Once the openings were completed, designated sampling stations were created up and down current from the east and west openings. Designated sampling stations were not created for the center opening as sampling results and turbidity data from the SAM locations had shown that water quality within the enclosure was as good as that in the St. Lawrence River by the time the center opening was complete.

SAM samples considered to represent conditions during removal of the sheet pile wall (these were also collected during the capping and post-capping period) were collected beginning on November 6, the day when work started on the initial (east) opening in the wall. As the number and size of the openings increased, the area formerly enclosed by the sheet pile wall began mixing with and eventually equilibrated with the hydraulic, chemical, and hydrodynamic conditions in the St. Lawrence River. For all practical purposes, the SAM locations were more or less representative of conditions in the river after about the 14^{th} of November.

Removal of the sheet pile wall was completed in 18 days (November 6 – November 25, 2001). The number of samples collected during this 18-day activity represented the most intense period of sampling for the entire project: 113 PCB samples, 93 PAH samples, and 100 PCDF samples were collected and analyzed. The results of these sampling activities are presented below.

PCBs

Unfiltered water samples were collected for PCB analyses from locations up current and down current from the initial openings in the wall, up and down current from the derrick barges, and from the internal SAM stations that were also monitored as a prelude to removing the wall. Table 4-13 summarizes PCB sampling during sheet pile removal activities. A total of 113 samples were collected and analyzed for PCBs, with a little fewer than half being collected from planned monitoring locations up and down current from the derrick barges pulling the steel from the river.

Table 4-13
PCB Sampling in the St. Lawrence River During Removal of Sheet Pile Wall

Derrick or Location	Station	Start	End	No. Samples	Detects	Action Level Exceedances
CAT 350	RRCATU	11/15/01	11/24/01	6	0	0
	RRCAT2	11/15/01	11/19/01	4	0	0
RELIEF	RRRELU	11/6/01	11/23/01	13	2	0
	RRREL2	11/6/01	11/23/01	14	3	0
IV SPOT	RRRY42	11/9/01	11/14/01	6	0	0
EAST OPENING	RREASTOPENINGU	11/10/01	11/14/01	5	0	0
	RREASTOPENING2	11/10/01	11/14/01	6	0	0
WEST OPENING	RRWESTOPENINGU	11/10/01	11/14/01	5	0	0
	RRWESTOPENING2	11/10/01	11/14/01	5	0	0
INTERIOR LOCATIONS *(OPEN TO RIVER)*	SAM01	11/6/01	11/20/01	15	2	0
	SAM02	11/6/01	11/6/01	1	0	0
	SAM04	11/6/01	11/20/01	16	6	0
	SAM05	11/6/01	11/20/01	17	5	0
	Total Water Sampling	*11/6/01*	*11/23/01*	*113*	*18*	*0*

PCBs were detected in 18 samples collected during sheet pile removal activities (Table 4-14). The majority of the detections were associated with samples collected on the 6th, 7th and 8th of November from the SAM locations within the enclosure. The maximum concentration detected was 0.87 µg/L, on November 6th from the SAM05 station. As stated above, the first (east) opening was not created until the 8th of November, and therefore most of these PCB detections were representative of water quality within the enclosure rather than in the river. The maximum concentration detected after November 8th was 0.4 µg/L from SAM04 on the 19th of November.

Table 4-14
Detected PCBs in Water Column Samples During Sheet Pile Removal

Location	Station	Date	Total PCBs
RELIEF	RRRELU	06-Nov-01	0.087
	RRRELU	17-Nov-01	0.073
	RRREL2	06-Nov-01	0.075
	RRREL2	09-Nov-01	0.125
	RRREL2	17-Nov-01	0.229
INTERIOR LOCATIONS (OPEN TO RIVER)	RRSAM01	06-Nov-01	0.588
	RRSAM01	08-Nov-01	0.082
	RRSAM04	06-Nov-01	0.704
	RRSAM04	07-Nov-01	0.53
	RRSAM04	08-Nov-01	0.461
	RRSAM04	09-Nov-01	0.172
	RRSAM04	17-Nov-01	0.103
	RRSAM04	19-Nov-01	0.414
	RRSAM05	06-Nov-01	0.845
	RRSAM05 (*dup*)	06-Nov-01	0.872
	RRSAM05	07-Nov-01	0.511
	RRSAM05	08-Nov-01	0.612
	RRSAM05	09-Nov-01	0.263

Note: All concentrations in µg/L PCB Action Level = 2 µg/L

PCB contamination levels detected during removal of the sheet pile wall were similar to those detected during dredging. PCBs were detected in about 6% of the water samples collected during dredging. If the samples collected on the 6th, 7th, and 8th of November are considered to represent water quality within the enclosure, PCBs were detected in about 6% of the samples collected during removal of the sheet pile wall. This similarity in the frequency of detection may reflect the influence of operational practices of an episodic nature (e.g., barge movement). It is important to note that no samples collected during either the dredging or sheet pile removal activities contained PCBs above the 2 µg/L action level.

PAHs

A total of 93 unfiltered water samples were collected for PAH analyses (Table 4-15) during removal of the sheet pile wall. These samples were a continuation of those begun in mid-October as a prelude to initiating removal of the sheet pile wall. Samples were collected from both the interior (SAM) locations, up and down current from the two initial openings in the sheet pile wall (east and west), and from the routine monitoring stations associated with the derrick barges (100 ft up current and 200 ft down current).

Table 4-15
PAH Sampling in the St. Lawrence River During Removal of Sheet Pile Wall

Derrick or Location	Station	Start	End	No. Samples	Detects	Action Level Exceedances
CAT 350	RRCATU	11/15/01	11/19/01	5	0	0
	RRCAT2	11/15/01	11/19/01	4	0	0
RELIEF	RRRELU	11/6/01	11/20/01	11	1	1
	RRREL2	11/6/01	11/20/01	12	0	0
	RRREL4	11/8/01	11/8/01	1	1	1
IV SPOT	RRRY42	11/9/01	11/13/01	5	0	0
EAST OPENING	RREASTOPENINGU	11/10/01	11/13/01	5	0	0
	RREASTOPENING2	11/10/01	11/13/01	4	0	0
WEST OPENING	RRWESTOPENINGU	11/10/01	11/13/01	4	0	0
	RRWESTOPENING2	11/10/01	11/13/01	4	0	0
INTERIOR LOCATIONS (open to river)	SAM01	11/7/01	11/19/01	12	0	0
	SAM02	--	--	--	--	--
	SAM04	11/7/01	11/19/01	13	1	1
	SAM05	11/7/01	11/19/01	13	0	0
	Total Water Sampling	*11/6/01*	*11/20/01*	*93*	*3*	*3*

PAHs were detected in three water samples collected during sheet pile removal: station RREL4 had 0.91 µg/L in a sample collected on November 8. Station RRELU had 0.54 µg/L in a sample collected November 15; and RRSAM04 had 0.406 µg/L in a sample collected on November 19. All 3 of these detections were above the action level, and these 3 samples were the only ones among the more than 1,000 water column samples collected from the St. Lawrence River during the project that exceeded action levels. For this reason, further evaluation of the circumstances surrounding each sample is warranted, and presented below.

Evaluation of PAH Results Exceeding Action Levels

The November 8th sample collected 400 ft down current from the Relief was collected at the same time as a 100 ft up current and 200 ft down current sample. Collection of the 400 ft sample was not required as all down current sampling associated with the derrick barges was based on collection of a sample from the 200 ft location only, unless there were extenuating circumstances (visible turbidity, access restrictions at the 200 ft location, etc.) There was no turbidity problem and the 200 ft location was accessible; the sampling crew mistakenly collected an additional sample that day. This error was not identified until November 9th, and the laboratories were notified to discard the 400 ft down current sample (the PCB sample was sent to Alcoa and the PAH sample to Mitkem, who was conducting quick turnaround PAH analyses to reduce the sample load on the Alcoa Lab), but Mitkem had already completed the analysis.

According to the turbidity log for the day, turbidity at the 400 ft down current station at the time of sample collection (14:20 hrs) was 2.56 NTUs on the Hach. Turbidity at the 200 ft down current and 100 ft up current stations was 2.56 NTUs and 2.87 NTUs, respectively. There was no visible turbidity and the Hach readings indicate that turbidity at the down current stations was essentially the same as the up current station. PAH contamination in the water column was shown in sampling conducted inside the enclosure to be related closely to suspended particulates, which in turn cause elevated turbidity readings.

If the contamination were related to the sheet pulling activities, elevated turbidity readings, or visual observations of turbid water would be expected.

The PAH results from the 200 ft down current and 100 ft up current stations were both non-detect. In particular, the absence of PAHs at the 200 ft down current station makes the detect at 400 ft down current somewhat suspect, and suggests it was not related to sheet pulling activities at the west opening. PAH contamination in the sediment near the west opening was very low, typically less than 1 ppm. The most plausible explanation for the contamination in this sample is that it was related to PAHs from other sources in the river, which include discharge of bilge water from passing ships, run-off from nearby towns, and the upstream waters of the Great Lakes.

The November 15th sample collected from the 100 ft up current station associated with the Relief fits into a similar pattern. There was essentially no turbidity (2.34 NTUs on the Hach) and no record of any turbidity problems. Turbidity at the 200 ft down current station was 3.27 NTUs, and the sample collected from this station was non-detect for PAHs. On that day, the Relief was pulling sheeting from the northern part of Area 3D, which did not contain appreciable levels of PAH contamination. Again, the presence of contamination was probably not related to sheet pile removal activities, given that contamination was detected in the up current sample, there was no turbidity in the water, and the down current sample was clean.

Neither the November 8th nor November 15th sample contained detectable levels of PCDFs. Sampling results from the entire set of SAM samples, collected both as a prelude to and during sheet pile wall removal, show that in all but 1 of the 36 SAM samples collected and analyzed for PAHs and PCDFs, PCDFs were detected whenever PAHs were also detected. The absence of PCDFs in the November 8th and November 15th samples provides additional information to suggest that the PAH contamination detected in these samples was not related to releases from the site.

The final sample with an action level exceedance, the November 19th sample from the SAM04 station, is also anomalous. At this point in time, the former enclosure was mostly open to the river; however, there was boat traffic related to continued removal of the wall. The turbidity associated with this sample was 6.38 NTUs, nearly 3 times higher than what was recorded at that station over the previous week. The same sample had detectable levels of PCBs and PCDFs, although neither of these contaminants exceeded action levels. The presence of detectable contamination and slightly elevated turbidity was consistent with observations regarding the correlation between turbidity and contamination based on the SAM sampling effort prior to initiating removal of the sheet pile wall.

RMC believes that the action level exceedance for PAHs on the 19th of November is the result of localized turbidity. Data indicate that this was an isolated occurrence and the resulting impact of the exceedance was negligible. No exceedances for PAHs were recorded in either of the two water column samples collected from the river that day, or in either of the other two SAM samples, indicating that the effects of the exceedance were localized to the vicinity of the SAM04 station.

To summarize, the PAHs detected above action levels on November 8th and November 15th are most likely not related to sheet pile removal activities. The exceedance on the 19th of November was site-related, but appears to be due to localized turbidity. These three samples were the only ones of the more than 1,000 water samples collected from the St. Lawrence River (or formerly enclosed locations open to the river) during the entire project that exceeded action levels.

PCDFs

A total of 100 unfiltered water samples were collected and analyzed for PCDFs during sheet pile wall removal activities (Table 4-16). These samples were a continuation of those begun in mid-October as a prelude to initiating removal of the sheet pile wall. Samples were collected from the interior (SAM) locations, up and down current from the 2 initial openings in the sheet pile wall (east and west), and from the routine monitoring stations associated with the derrick barges (100 ft up current and 200 ft down current). Sampling results are presented in Appendix D.

Table 4-16
PCDF Sampling in the St. Lawrence River During Removal of Sheet Pile Wall

Derrick or Location	Station	Start	End	No. Samples	Detects	Action Level Exceedances
CAT 350	RRCATU	11/15/01	11/249/01	5	0	0
	RRCAT2	11/15/01	11/19/01	4	0	0
RELIEF	RRRELU	11/6/01	11/20/01	12	0	0
	RRREL2	11/6/01	11/20/01	12	0	0
IV SPOT	RRRY42	11/9/01	11/14/01	6	0	0
EAST OPENING	RREASTOPENINGU	11/10/01	11/13/01	5	0	0
	RREASTOPENING2	11/10/01	11/13/01	6	0	0
WEST OPENING	RRWESTOPENINGU	11/10/01	11/14/01	5	0	0
	RRWESTOPENING2	11/10/01	11/14/01	5	0	0
INTERIOR LOCATIONS (open to river)	SAM01	11/6/01	11/19/01	12	2	0
	SAM02	11/6/01	11/6/01	1	0	0
	SAM04	11/6/01	11/20/01	13	4	0
	SAM05	11/6/01	11/19/01	14	4	0
	Total Water Sampling	*11/3/01*	*11/20/01*	*100*	*10*	*0*

PCDFs were detected in 10 samples (Table 4-17). All detected concentrations were below the action levels (which were based on the MDL-based detection limits for PCDF analyses as described in Section 4.4).

Table 4-17
Detected PCDFs in Water Column Samples During Sheet Pile Wall Removal

Station	Date	Analyte	Result (pg/L)		Action Level*
RRSAM05	11/6/01	2,3,4,7,8-PCDF	5.06	J	25
	11/6/01	2,3,7,8-TCDF	2.54	J	10
RRSAM05 (*dup*)	11/6/01	2,3,4,7,8-PCDF	7.91	J	25
RRSAM01	11/6/01	2,3,7,8-TCDF	2.2	J	10
RRSAM05	11/7/01	2,3,4,7,8-PCDF	5.07	J	25
	11/7/01	2,3,7,8-TCDF	2.73	J	10
RRSAM04	11/7/01	2,3,7,8-TCDF	2.26	J	10
RRSAM04	11/8/01	2,3,7,8-TCDF	2.63	J	10
RRSAM05	11/8/01	2,3,7,8-TCDF	3.45	J	10
RRSAM04	11/16/01	2,3,7,8-TCDF	2.31	J	10
RRSAM01	11/16/01	2,3,4,7,8-PCDF	5.26	J	25
RRSAM04	11/19/01	1,2,3,4,7,8-HxCDF	7.81	J	25
	11/19/01	2,3,4,7,8-PCDF	11.7	J	25
	11/19/01	2,3,7,8-TCDF	5.53	J	10

Note: * Action levels based on homologue-specific, Method Detection Limits for Method 8290 (SW-846)

The only positive detections for PCDFs were associated with interior (SAM) locations, and the majority of these (7 samples out of 10) were in samples collected during the first few days that the first (east) opening was being constructed (November 6–8, 2001). Consequently, the detections associated with these samples more accurately reflect water quality within the enclosure rather than the St. Lawrence River. The absence of any detection of PCDFs in samples collected from monitoring stations outside the enclosure confirms previous conclusions that there was no release of contaminated sediment following removal of the sheet pile wall.

4.2 WATER INTAKE MONITORING

Potable water intakes used by the SRMT and for the GM and RMC plants were sampled during dredging and sheet pile removal to verify that the remediation activities were not having any impact on the quality of water supplies obtained from the St. Lawrence River. The SRMT water treatment facility is located approximately 3.9 miles downstream of the remediation area. The GM plant intake lies approximately 0.6 miles downstream. The RMC intake lies just west of the remediation area but is in the zone of reverse current flow such that the river in this area is flowing westward (upstream), which placed the RMC intake down current of the western part of the remediation area. All intake sampling locations are shown in Figure 4-8.

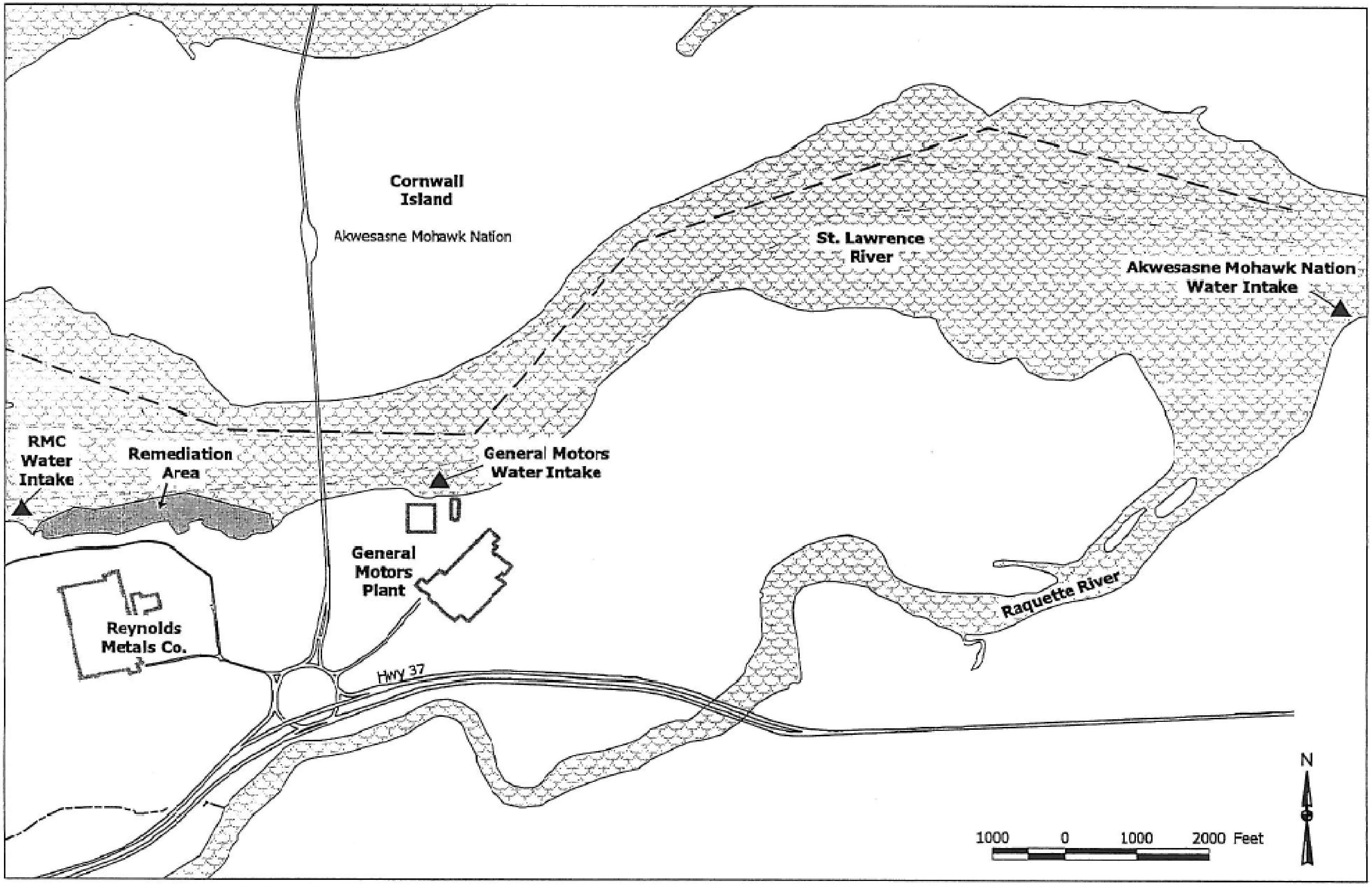


Figure 4-8
Water Intake Sampling Locations

In accordance with the EMP, water grab samples were collected from sample ports of raw (untreated) and filtered (treated) water within the SRMT Water Treatment Building while samples of raw (untreated) water only were obtained from sampling ports inside the GM and RMC water plants. Samples of treated water were later obtained from an approximate one-week period from the GM and RMC water plants during mid-October, in response to a lab contamination issue that resulted in the erroneous reporting of detections of PCBs from several of the sampling locations. This issue is discussed in further detail below.

During dredging operations involving the removal of sediment with >500 ppm PCBs (including the Area C hotspots), water samples were collected from the designated locations daily. Samples were collected on a weekly basis during all other dredging activities. Daily sampling was resumed during removal of the sheet pile wall, and continued up until the final week of wall removal. PAH analysis were to be discontinued if elevated levels were not observed in the daily samples collected during the initial weeks of dredging; however, in response to EPA concerns, RMC continued PAH analyses up until the final weeks of dredging in early October.

The water quality action levels as stated in the EPA-approved EMP were non-detectable PCB and PAH concentrations, with detection limits of 0.065 µg/L and 0.2 µg/L, respectively. The water intake for the Mohawk Council of Akwesasne (located downstream of SRMT) was to be sampled if any of the action levels were exceeded at the SRMT water intake. There were no exceedances, and thus no samples were collected from the Mohawk Council of Akwesasne.

As shown in Table 4-18, a total of 261 intake samples were collected and analyzed for PCBs (including field duplicates and split samples sent by RMC to separate labs). Sampling for PCBs spanned the entire spectrum of dredging activities from the beginning of environmental dredging in mid-June until dredging was stopped on October 16. PCB sampling was resumed on November 6 when the initial opening in the sheet pile wall was begun, and continued until nearly 90% of the wall had been removed. Only one sample had a reported detection of PCBs; however, this result is believed to be spurious for the reasons examined below.

Table 4-18
Summary of Water Intake Sampling Activities

			PCB Sampling			PAH Sampling		
System	**Type**	**Station ID**	**Start**	**End**	**#**	**Start**	**End**	**#**
SRMT	*Raw*	RRMTIS	6/20/01	11/20/01	65	6/20/01	10/3/01	30
	Treated	RRMTTS	6/20/01	11/20/01	66	6/20/01	10/3/01	32
GM Water Supply	*Raw*	RRGMIS	6/20/01	11/20/01	54	6/20/01	10/3/01	23
	Treated	RRGMTS	10/3/01	10/9/01	13	--	--	--
RMC Water Supply	*Raw*	RRRMIS	6/20/01	10/17/01	51	6/20/01	10/3/01	32
	Treated	RRRMTS	10/3/01	10/9/01	12	--	--	--
Total Number of Intake Samples			*6/20/01*	*11/20/01*	*261*	*6/20/01*	*10/3/01*	*117*

A total of 117 intake samples were also collected and analyzed for PAHs. PAH sampling was conducted only during dredging operations. No PAHs were detected in any of the 117 water intake samples, which was the rationale for ending PAH sampling in early October.

Reported PCB Detections in Water Intake Samples

Preliminary results for PCBs from four water samples collected on the 19th of September and sent to Galson Laboratories indicated positive detections of Aroclor 1260. A sample on September 27th also had a positive detection of Aroclor 1260 (Table 4-19). No previous samples had identified any PCBs above detection limits of 0.05 to 0.065 µg/L. These results are discussed in detail below.

Table 4-19
Selected Galson Laboratory Results for Water Intake PCB Samples

Date	Station	Sample Type	Analyte	Reported Detection	Lab Qualifier
9/19/01	RRGMIS	*GM raw water*	Aroclor 1260	0.51	B
9/19/01	RRMTTS	*SRMT treated water*	Aroclor 1260	0.25	B
9/19/01	RRRMIS	*RMC raw water*	Aroclor 1260	0.38	B
9/19/01	RRRMIS (*dup*)	*RMC raw water*	Aroclor 1260	0.44	B
9/27/01	RRMTTS	*SRMT treated water*	Aroclor 1260	0.06	J

Samples were sent to Galson on August 22, 26, and 29; September 6, 12, 19 and 27. Prior to August 22, the Alcoa Lab was analyzing all of the intake PCB samples. Samples were sent to Galson in an attempt to reduce the volume of samples analyzed by the Alcoa Lab, which was receiving dozens of water samples and even larger numbers of sediment samples each day during this period of the dredging. Galson was supposed to do the PCB analyses on a quick-turnaround basis; however, delays eventually built up within this laboratory as well, and by the middle of September, there was a considerable lag time between sample receipt at the lab and transmittal of preliminary results to RMC. Data from the September 19th sampling event were not received until September 28th.

As shown in Table 4-19, these results indicated low levels of Aroclor 1260 in the GM, RMC, and SRMT water samples. Even though the laboratory had qualified the September 19th data based on blank contamination in both its method and rinsate blanks, there was significant concern that the water supplies had PCB contamination, which in the case of the GM result exceeded the PCB MCL of 0.5 µg/L. In response, RMC undertook an expanded sampling and analysis program to verify that there was no PCB contamination in the water supplies of GM, SRMT or the RMC plant.

This expanded program involved the collection of daily samples of both raw and treated water for PCB analysis at all three water plants. Each sample was split, with analyses at the Alcoa Lab and Friend Laboratories (who conducted other analyses for the project). Daily split samples began on October 2 and continued for the next week, ending on October 9. A total of 80 samples were analyzed for PCBs during this period, and all results were non-detect at levels of 0.05 to 0.065 µg/L. These results confirmed that there were no PCBs in the SRMT, GM plant or RMC plant water supplies.

In the course of data validation efforts completed during preparation of this Completion Report, the September 19th data was assigned a review qualifier of "U" or non-detect. This determination was consistent with EPA guidances used for data assessment of PCB analyses by Method 8082. The September 27th data remained an unqualified detection as there was apparently no blank contamination reported by the lab for this sample; however, it is also suspect given that the same Aroclor was detected and the analysis was conducted at essentially the same time that Galson was having the blank contamination problems cited for the September 19th samples.

In summary, the remediation activities conducted in 2001 did not have any impact on downstream water supplies in the St. Lawrence River. Taken together the monitoring data support that dredging and removal of the sheet pile wall did not introduce any PCB or PAH contamination into water supplies for GM, RMC, or the SRMT.

4.3 WASTEWATER TREATMENT PLANT DISCHARGES

Monitoring of water treatment plant (WTP) discharges was conducted to verify compliance with the plant's Final Effluent Limitations and Monitoring Requirements issued by NYSDEC. Sampling was also conducted from intermediate steps of the process to verify the performance of the system and trouble-shoot problems that developed during operations due to high solids loading. Monthly reports were issued to DEC that presented all of the monitoring results and identified any issues or concerns related to discharges from the WTP. Copies of these monthly reports are presented in Appendix I.

4.4 MONITORING INSIDE THE SHEET PILE ENCLOSURE

Monitoring was conducted inside the sheet pile wall to provide information concerning water quality and sediment resuspension. Results of this monitoring are discussed below.

4.4.1 Turbidity Monitoring Inside the Sheet Pile Enclosure

Daily turbidity measurements were completed at 12 to 19 different stations inside the sheet pile enclosure during a portion of the dredging operations. The number and locations of the stations depended on the dredging activities occurring at the time the monitoring team was able to collect the measurements. The data summarized in Figure 4-9 reflect 48 days of monitoring (July 21 – September 26, 2001) during which a total of 820 turbidity measurements were collected.

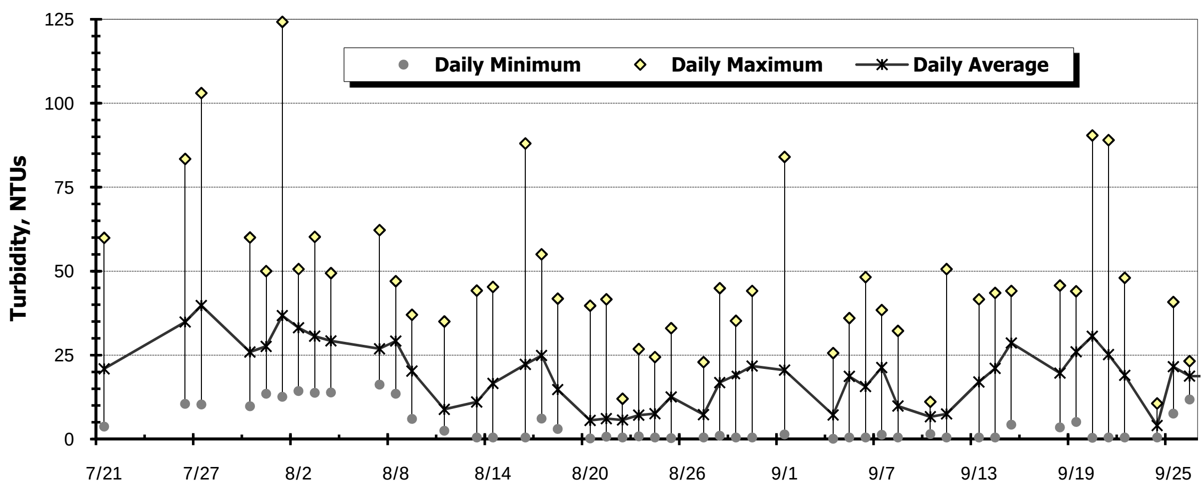


Figure 4-9
Daily Turbidity Inside the Sheet Pile Enclosure During Dredging

Discrete turbidity measurements inside the enclosure were eventually discontinued at the end of September once the trend present in the graph became apparent. This trend showed that average turbidity inside the enclosure was typically less than 25 NTUs and that maximum turbidity was generally below 50

NTUs. The higher turbidity values were obtained in proximity to derrick barges engaged in dredging operations.

Continuous turbidity measurements were also collected inside the sheet pile enclosure during dredging operations using a data-logging Hydrolab turbidimeter. The majority of these measurements were collected at a fixed location in Area D, at the northwest corner of the Area C silt curtain. The instrument was attached to a silt curtain anchor post and monitored turbidity at a depth of 50% of the water depth at that point. The data logging turbidimeter was operated from July 27 to November 24, 2001, and measurements were collected every hour; data are in Appendix D.

4.4.2 Water Column Sampling Inside the Sheet Pile Enclosure

As required in the EPA-approved EMP, the water column inside the sheet piling enclosure was sampled once per week during active dredging operations and analyzed for PCBs, PAHs and PCDFs. Per instructions from EPA, the sample was field filtered using a 0.45 µm filter in order to limit the analysis to dissolved contaminants only. The results of this sampling were expected to provide an indication as to whether dissolved-phase contamination was present and, if so, whether it is accumulating over time. This information was to be factored into the scope of monitoring during removal of the sheet pile wall, but in fact the filtered sample results played no role in the decisions related to the timing and methods for removal of the wall.

Collection of weekly samples at the RRSAM01 location (Figure 4-10) began on June 20, 2001 (Table 4-20). Filtered samples were collected from 50% of the water column depth at this location once a week through mid-October, at which point both the frequency and number of samples collected increased. Unfiltered samples were collected beginning with the weekly sample on October 8, 2001. Beginning October 15 and continuing through November 20, daily, unfiltered samples were collected at three locations inside the sheet pile wall, RRSAM01, RRSAM04, and RRSAM05 (collectively referred to as the "SAM" samples).

Table 4-20
Water Column Sampling Inside the Sheet Pile Wall During Dredging and Capping

				Number of Samples		
Station	**Type**	**Start**	**End**	**PCBs**	**PAHs**	**PCDFs**
RRSAM01	*Filtered*	6/20/01	10/10/01	17	17	10
	Unfiltered	10/15/01	11/05/01	21	21	21
RRSAM02	*Unfiltered*	9/7/01	9/7/01	1	--	--
RRSAM03	*Unfiltered*	9/7/01	9/7/01	1	--	--
RRSAM04	*Unfiltered*	10/8/01	11/05/01	21	21	21
RRSAM05	*Unfiltered*	10/8/01	11/05/01	21	21	21
Total No. Water Samples		*6/20/01*	*11/05/01*	*82*	*80*	*80*

Water sampling results from the SAM locations are presented in Appendix D.

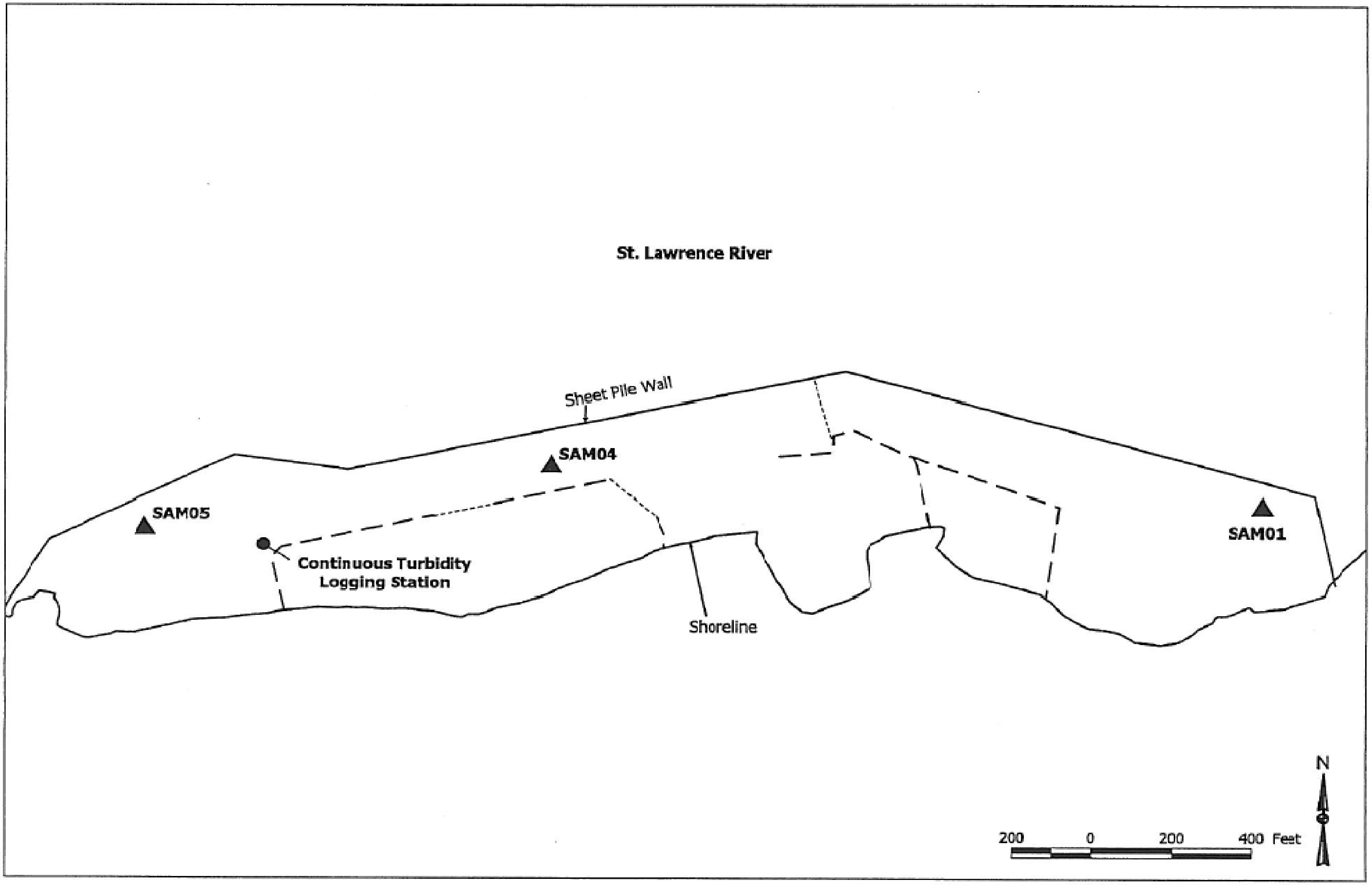


Figure 4-10
SAM Sample Locations

The initial opening in the sheet pile wall was begun on November 6, and SAM sampling results generated from this date forward were discussed in the context of monitoring during removal of the sheet pile wall. The discussion of results in this section is therefore limited to SAM samples collected between June 20 and November 5, 2001.

Samples collected from the SAM02 and SAM03 locations were one-time sampling events related to the internal turbidity measurements described in the preceding section. PCB results from these samples provided an early indication of contamination associated with turbid water, later confirmed through the large number of unfiltered samples collected between mid-October and early November.

PCBs

The weekly filtered samples for PCB analyses began showing low levels of PCBs in August (Table 4-21). Total PCB concentrations of 0.2-0.5 µg/L were detected in the SAM01 samples, collected in the eastern part of the enclosure (Area A), through the end of the dredging project in mid-October. Higher levels of PCBs were detected once unfiltered samples began being collected, which was expected given the propensity that PCBs have for sorption to sediment and organic matter.

Figure 4-11 shows PCB results from the SAM samples beginning on August 1 and continuing through the initiation of sheet pile removal activities on November 6. The chart shows that concentrations in unfiltered samples declined rapidly after the end of dredging on October 16, 2001.

During the approximate week-long capping effort in Area C, unfiltered PCB concentrations increased slightly, but generally remained below the 2 µg/L action level. Concentrations continued to decline through early November, allowing for the creation of the initial openings in the sheet pile wall.

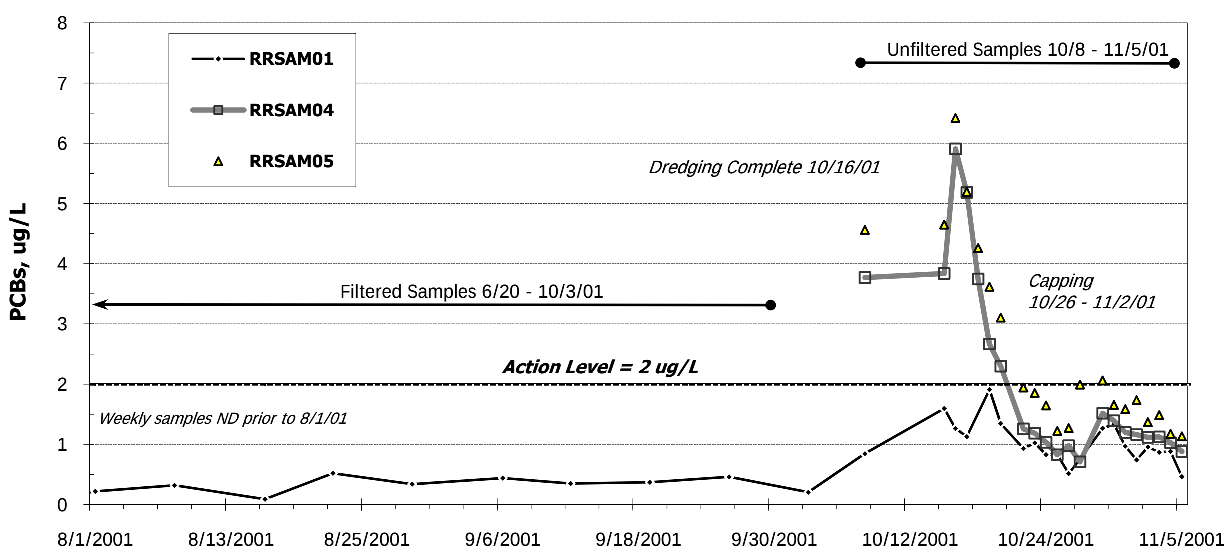


Figure 4-11
PCBs in SAM Samples During Dredging and Capping

The chart also shows that PCB concentrations were typically highest at the SAM04 and SAM05 locations, located in the central and western portions of the enclosure, respectively. These areas were associated with consistently higher turbidity (Figure 4-12), and thus unfiltered samples had higher concentrations of suspended solids, which in turn resulted in higher levels of PCB contamination.

Table 4-21
Detected PCBs in Water Samples from Inside the Sheet Pile Wall

Date	Type	Total PCBs (µg/L) SAM01	SAM04	*SAM05*
8/1/2001	*Filtered*	0.22	Not Sampled (NS)	Not Sampled (NS)
8/8/2001	*Filtered*	0.32		
8/16/2001	*Filtered*	0.08		
8/22/2001	*Filtered*	0.52		
8/29/2001	*Filtered*	0.34		
9/6/2001	*Filtered*	0.44		
9/12/2001	*Filtered*	0.35		
9/19/2001	*Filtered*	1.12		
9/26/2001	*Filtered*	0.38		
10/3/2001	*Filtered*	0.21		
10/8/2001	*Unfiltered*	0.85	3.77	4.56
10/10/2001	*Filtered*	0.21	NS	NS
10/15/2001	*Unfiltered*	1.60	3.84	4.65
10/16/2001	*Unfiltered*	1.26	5.91	6.428
10/17/2001	*Unfiltered*	1.13	5.18	5.19
10/18/2001	*Unfiltered*	NS	3.75	4.26
10/19/2001	*Unfiltered*	1.91	2.67	3.62
10/20/2001	*Unfiltered*	1.35	2.30	3.10
10/22/2001	*Unfiltered*	0.93	1.26	1.94
10/23/2001	*Unfiltered*	1.02	1.19	1.85
10/24/2001	*Unfiltered*	0.83	1.03	1.65
10/25/2001	*Unfiltered*	0.83	1.15	1.22
10/27/2001	*Unfiltered*	0.75	0.71	1.99
10/31/2001	*Unfiltered*	0.97	2.39	1.58
11/1/2001	*Unfiltered*	0.74	1.16	3.47
11/2/2001	*Unfiltered*	0.96	1.12	1.37
11/3/2001	*Unfiltered*	0.87	1.12	1.48
11/4/2001	*Unfiltered*	0.84	1.03	1.17
11/5/2001	*Unfiltered*	0.46	0.88	1.13

PCB Action Level = 2 µg/L

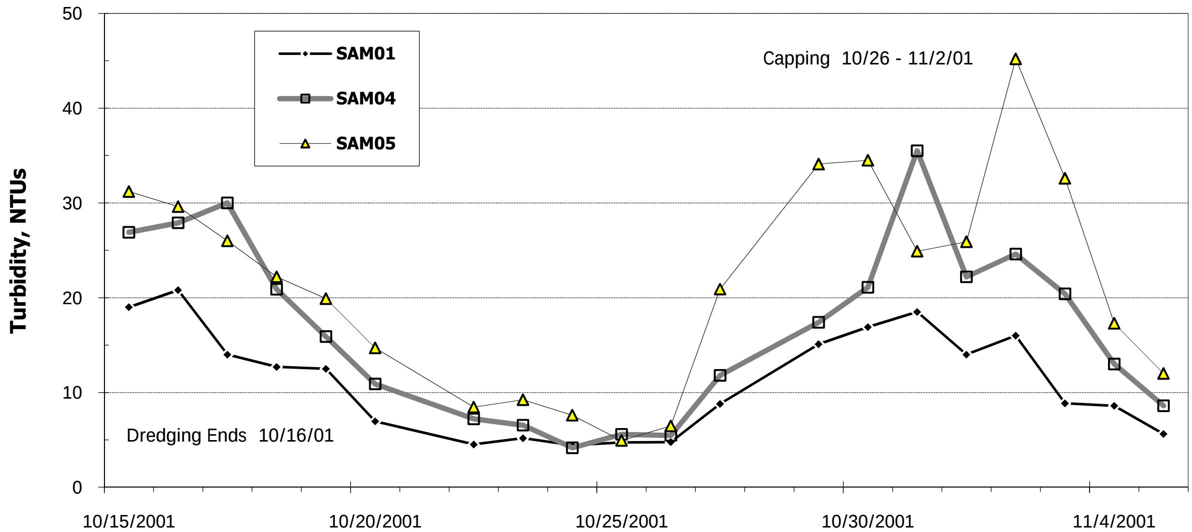


Figure 4-12
SAM Station Turbidity October 15 – November 5, 2001

The turbidity chart also shows the impact from capping in the central (SAM04) and western (SAM05) portions of the enclosure between October 26 and November 2, 2001. Turbidity levels dropped relatively quickly at the conclusion of capping, just as they had done after dredging ended.

PAHS

The pattern for PAHs in the filtered samples collected weekly from inside the enclosure was similar to that seen for the PCBs. Low levels of PAHs were occasionally detected in these samples in July and August (Table 4-22). In the unfiltered samples, PAHs were consistently detected at all three SAM locations, with the highest levels in the central (SAM04) and western (SAM05) samples.

Table 4-22
Detected PAHs in Water Samples from Inside the Sheet Pile Wall

		Total PAHs (µg/L)		
Date	**Type**	**SAM01**	**SAM04**	**SAM05**
7/19/01	*Filtered*	0.22	*Not Sampled*	*Not Sampled*
7/25/01	*Filtered*	0.21		
8/22/01	*Filtered*	0.31		
10/8/01	*Unfiltered*	0.70	4.59	3.98
10/15/01	*Unfiltered*	1.58	2.61	3.23
10/16/01	*Unfiltered*	1.95	5.16	4.84
10/17/01	*Unfiltered*	0.79	5.50	3.61
10/18/01	*Unfiltered*	0.81	3.88	4.10
10/19/01	*Unfiltered*	0.82	1.43	3.03
10/20/01	*Unfiltered*	0.36	0.79	1.67
10/25/01	*Unfiltered*	0.15	0.37	0.46
10/26/01	*Unfiltered*	0.30	0.40	0.73

Table 4-22 (cont.)

		Total PAHs (µg/L)		
Date	**Type**	**SAM01**	**SAM04**	**SAM05**
10/27/01	*Unfiltered*	0.28	1.05	2.11
10/29/01	*Unfiltered*	1.06	1.73	1.44
10/30/01	*Unfiltered*	1.98	0.93	2.46
10/31/01	*Unfiltered*	0.96	0.52	1.11
11/1/01	*Unfiltered*	0.24	0.59	0.64
11/2/01	*Unfiltered*	0.44	0.61	0.69
11/3/01	*Unfiltered*	0.27	0.52	ND

PAH Action Level = 0.2 µg/L

Figure 4-13 shows PAH results from the SAM samples beginning in mid-July, when the first detection was reported, and continuing through the initiation of sheet pile wall removal activities on November 6, 2001. Like the PCBs, the PAHs declined rapidly after the end of dredging on October 16, and then increased slightly during the capping operations between October 26 and November 2. Concentrations then decreased again following the end of capping, enabling the initiation of wall removal activities.

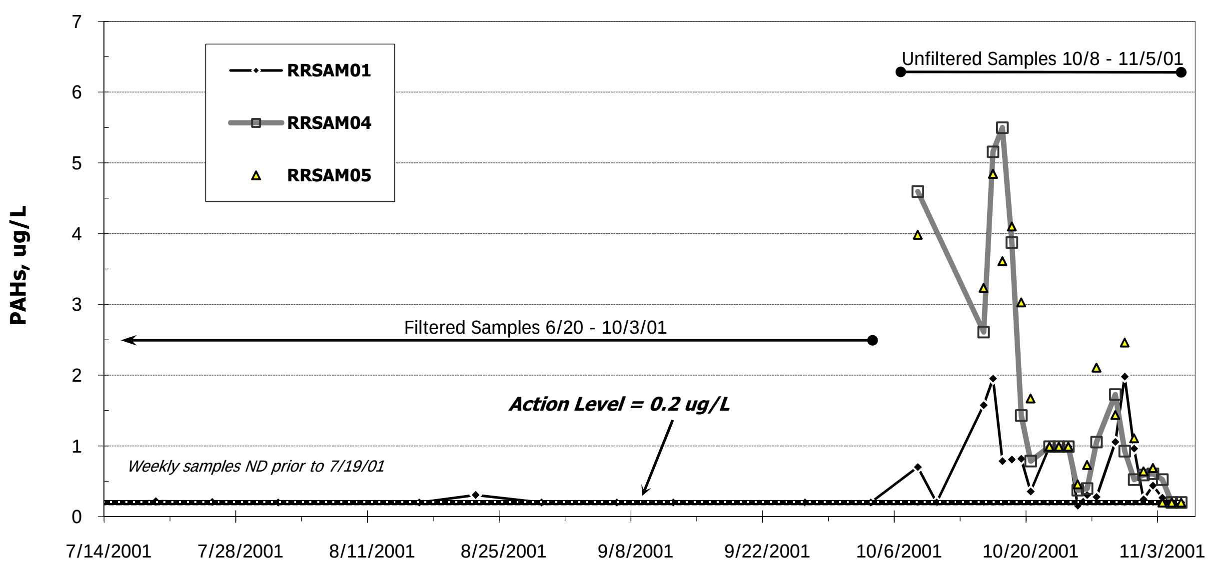


Figure 4-13
PAHs in SAM Samples During Dredging and Capping

PAH contamination in the unfiltered samples was also closely related to turbidity. In general, it appeared that once the turbidity dropped below 10-15 NTUs that the PAHs would be below the 0.2 µg/L action level in the unfiltered samples. This relationship was a factor in determining the timing and procedures for opening the sheet pile wall.

PCDFs

PCDFs were detected in only one of the filtered SAM01 samples (August 8, 2001), indicating these were the least likely contaminants to accumulate as dissolved species in the water column. In contrast, when unfiltered samples were collected, PCDFs were found to be very persistent contaminants—at low, part per quadrillion levels—due possibly to their sorption to clay particles or small molecules of naturally-occurring organic matter. Table 4-23 lists the positive detections for PCDFs between June 20 and November 5, 2001.

Table 4-23
Detected PCDFs in Water Samples from Inside the Sheet Pile Wall

		Total PCDFs (pg/L)		
Date	**Type**	**SAM01**	**SAM04**	**SAM05**
8/8/2001	*Filtered*	4.02 J	*NS*	*NS*
10/8/2001	*Unfiltered*	21.97	181.89	174.87
10/15/2001	*Unfiltered*	54.49	153.3	170.07
10/16/2001	*Unfiltered*	49	283.18	182.27
10/17/2001	*Unfiltered*	40.48	229.52	200.47
10/18/2001	*Unfiltered*	34.84	155.72	142.01
10/19/2001	*Unfiltered*	155.54	91.98	127.28
10/20/2001	*Unfiltered*	41.21	*NS*	81.93
10/22/2001	*Unfiltered*	20.72	37.7	56.24
10/23/2001	*Unfiltered*	99.12	22.43	38.08
10/24/2001	*Unfiltered*	14.09	22.15	19.92
10/25/2001	*Unfiltered*	13.04	19.81	25.58
10/26/2001	*Unfiltered*	19.73	29.04	44.8
10/27/2001	*Unfiltered*	29.31	27.23	59.9
10/29/2001	*Unfiltered*	21.93	35.88	45.55
10/30/2001	*Unfiltered*	19.28	25.46	34.86
10/31/2001	*Unfiltered*	16.48	24.61	34.33
11/1/2001	*Unfiltered*	14.5	22.91	39.37
11/2/2001	*Unfiltered*	12.83	3.84	12.7
11/3/2001	*Unfiltered*	10.25	12.45	13.72
11/4/2001	*Unfiltered*	8.95	9.4	10.05
11/5/2001	*Unfiltered*	2.09	16.72	21.4

Action levels for the PCDFs were selected in consultation with EPA. In the EMP, the action levels in water for PCDFs was listed as the practical quantitation limits or PQLs. Because of the range of PQLs available, which are a function of the matrix, laboratory methods, laboratory QC results, and even the analyst conducting the analyses, EPA determined that the PQLs would be based on the current SW-846 method detection limits (MDLs) for the analytical method being used to analyze for PCDFs in water (i.e., Method 8290). These limits also form the basis for the drinking water MCLs for dioxins, which are also analyzed for using Method 8290 (as a point of reference, the MCL for 2,3,7,8 tetrachlorodibenzo-p-dioxin, considered the most toxic of dioxin isomers, is 30 pg/L). The 8290 MDLs for PCDFs in water are summarized in Table 4-24.

Table 4-24
Method Detection Limits for PCDFs in SW-846 Method 8290

Homologue	Congener	MDL (pg/L)
Tetra-chlorinated dibenzofurans (TCDF)	2,3,7,8-Tetrachlorodibenzofuran	10
Penta-chlorinated dibenzofurans (PeCDF)	1,2,3,7,8-Pentachlorodibenzofuran	25
	2,3,4,7,8-Pentachlorodibenzofuran	25
Hexa-chlorinated dibenzofurans (HxCDF)	1,2,3,6,7,8-Hexachlorodibenzofuran	25
	1,2,3,7,8,9-Hexachlorodibenzofuran	25
	1,2,3,4,7,8-Hexachlorodibenzofuran	25
	2,3,4,6,7,8-Hexachlorodibenzofuran	25
Hepta-chlorinated dibenzofurans (HpCDF)	1,2,3,4,6,7,8-Heptachlorodibenzofuran	25
	1,2,3,4,7,8,9-Heptachlorodibenzofuran	25
Octo-chlorinated dibenzofurans (OCDF)	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	50

Note: pg/L = parts per quadrillion

Figure 4-14 shows PCDF results from the SAM samples beginning in early August, when the first detection was reported, and continuing through the initiation of sheet pile wall removal activities on November 6, 2001. Like the PCBs and PAHs, the PCDFs declined rapidly after the end of dredging on October 16, and then increased slightly during the capping operations between October 26 and November 2. Concentrations decreased following the end of capping, but at a somewhat slower rate than observed with the PCBs and PAHs.

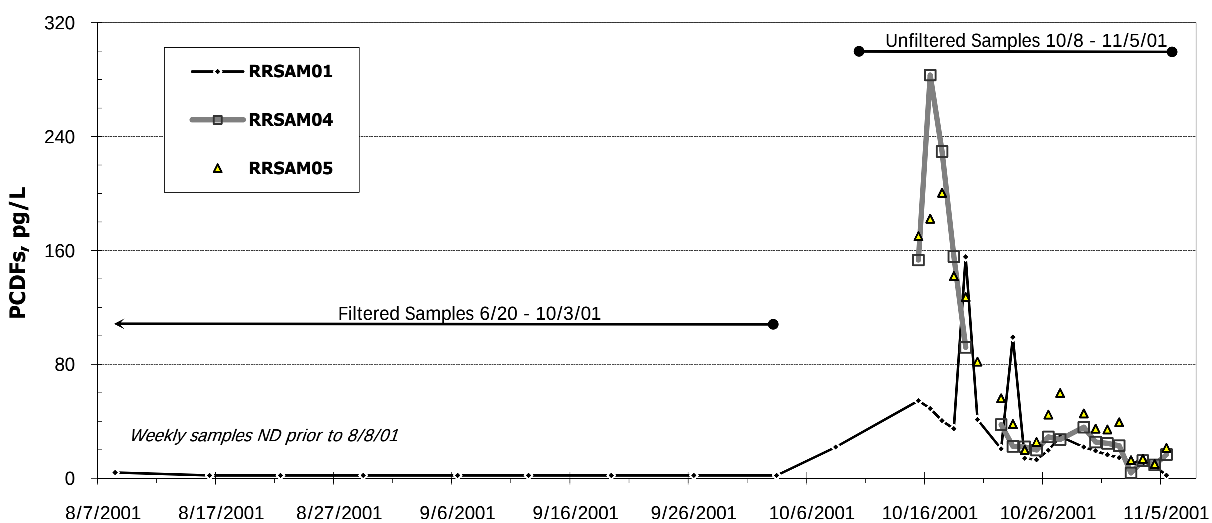


Figure 4-14
PCDFs in SAM Samples During Dredging and Capping

4.5 ONSHORE MONITORING ACTIVITIES

4.5.1 Boundary Air Monitoring

Boundary air monitoring for particulates (PM_{10}) and PCBs was conducted on a near-continuous basis throughout the duration of the river remediation project. Onsite air monitoring stations were established at a background location, downwind of the sediment storage pens and East Dock area, downwind of the onsite landfill, adjacent to the Interim Storage Pad, and along the eastern boundary of the RMC property near the International Bridge. Offsite monitoring stations were established at two locations on the SRMT Reservation: Raquette Point Road and near the International Bridge on Cornwall Island. Several additional locations were monitored for brief durations on the SRMT Reservation in response to tribal concerns regarding air quality issues (discussed in detail below). All boundary air monitoring stations are shown on Figure 4-15.

4.5.1.1 Airborne PCB Monitoring

Air monitoring for PCBs was conducted during all activities involving the dredging, handling, transport or disposal of PCB-contaminated sediment. The sampling was conducted in accordance with the EPA *Reference Method for the Determination of Organochlorine Pesticides and Polychlorinated Biphenyls in Ambient Ai*r (EPA 1988). A modified high-volume sampler (200- to 280-L/min flow rate) and a 4-in.-diameter glass fiber filter followed by a polyurethane foam (PUF) cartridge were used to collect PCBs in ambient air. Samples were collected over a 24-hr period. Both glass fiber filter and the cartridge were sent to an offsite laboratory for PCB analysis.

In accordance with the EMP, boundary air monitoring for PCBs was conducted daily for the first 4 to 5 weeks of dredging. No problems were identified, and the analyses were then cut back to a frequency of once per week. Samples continued to be collected daily but only one sample per week was sent to the laboratory for PCB analysis. At the end of the week, the air sample collected on the day with the highest ambient dust readings (discussed below) was sent for analysis. The analysis of daily samples resumed in August 2001 for the background, sediment pens and landfill station, in response to action level exceedances at the sediment pens station. The frequency of analyses for these and the other stations, including the SRMT stations, varied for the remainder of the project as shown in Figure 4-16, which identifies the sampling dates for all boundary air PCB samples.

A total of 482 air samples were ultimately collected and analyzed for PCBs using EPA Method T04 (Table 4-25) during the 147 days in which boundary air sampling was conducted; the results are plotted on Figure 4-17. These samples reflect ambient air conditions during all phases of the dredging, capping, sediment handling, and sheet pile removal activities. Although most of the samples were collected at the onsite stations, nearly one-third were collected from stations on the SRMT Reserve. Air sampling results are presented in Appendix D.

Table 4-25
Summary of Boundary Air Sampling for PCBs

Location	Station	Start	End	# Samples	Detects	*Range* (ng/m^3)	Action Level Exceedances
Background	RRBASC	6/8/01	11/21/01	95	88	.3U – 13.5	0
Landfill	RRLASC	6/22/01	11/15/01	56	53	.3U – 82	0
Sediment Pens	RRSASC	6/8/01	11/21/01	135	134	.3U – 724	53
Interim Storage Pad	RRIASC	9/8/01	11/7/01	29	29	4 – 203	5
RMC Boundary	RRGASC	10/11/01	11/7/01	27	26	.3U – 60	0
SRMT Reserve	Raquette Pt Rd	6/15/01	11/1/01	81	69	.2U – 23	0
	Cornwall Island -Bridge	7/20/01	11/1/01	58	53	.2U – 9	0
	Cornwall Island - Dean Pt	7/25/01	7/25/01	1	1	7.7	0
Total No. of PCB Air Samples		*6/8/01*	*11/21/01*	*482*	*453*	--	*58*

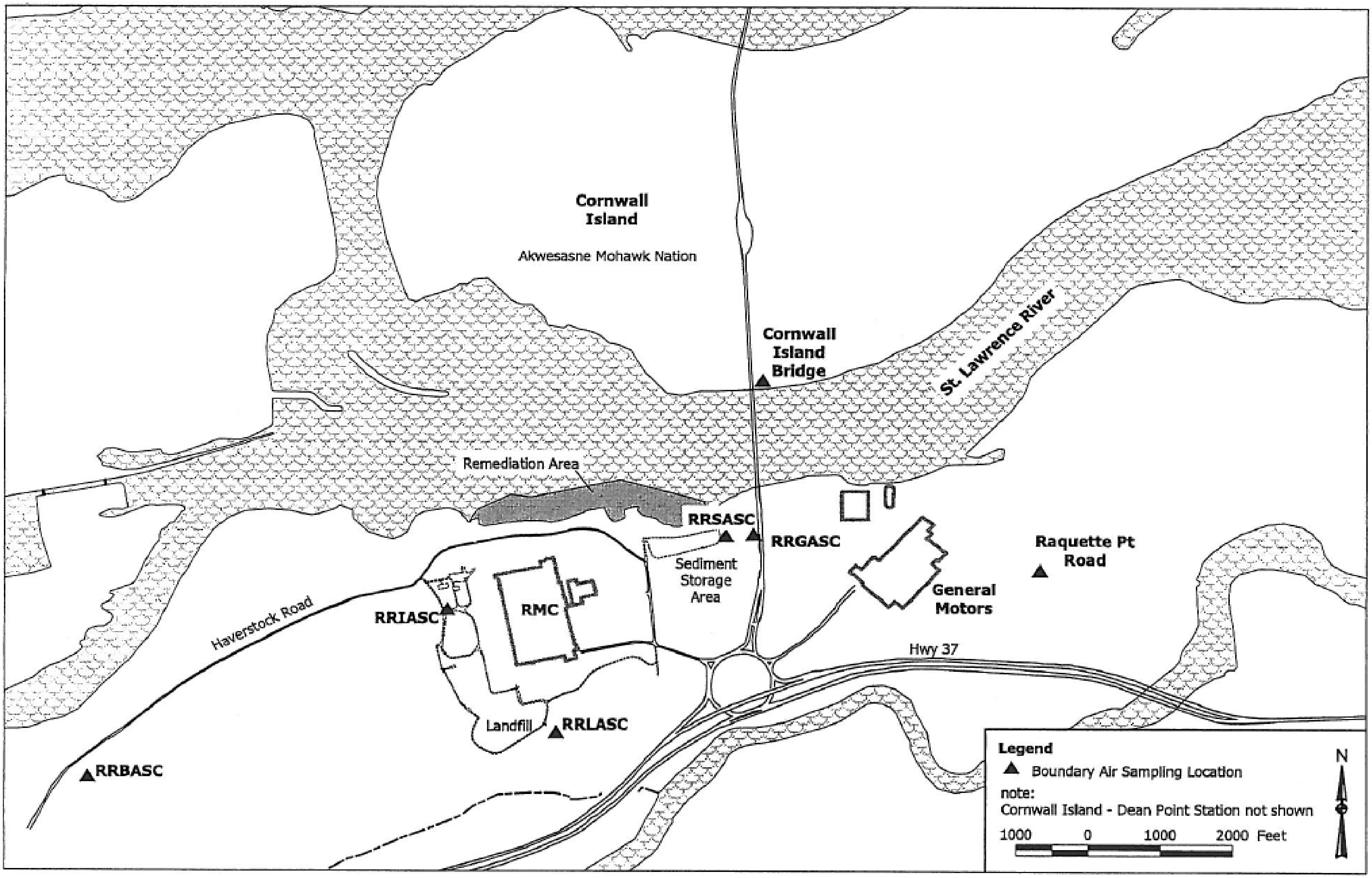


Figure 4-15
Boundary Air Monitoring Stations

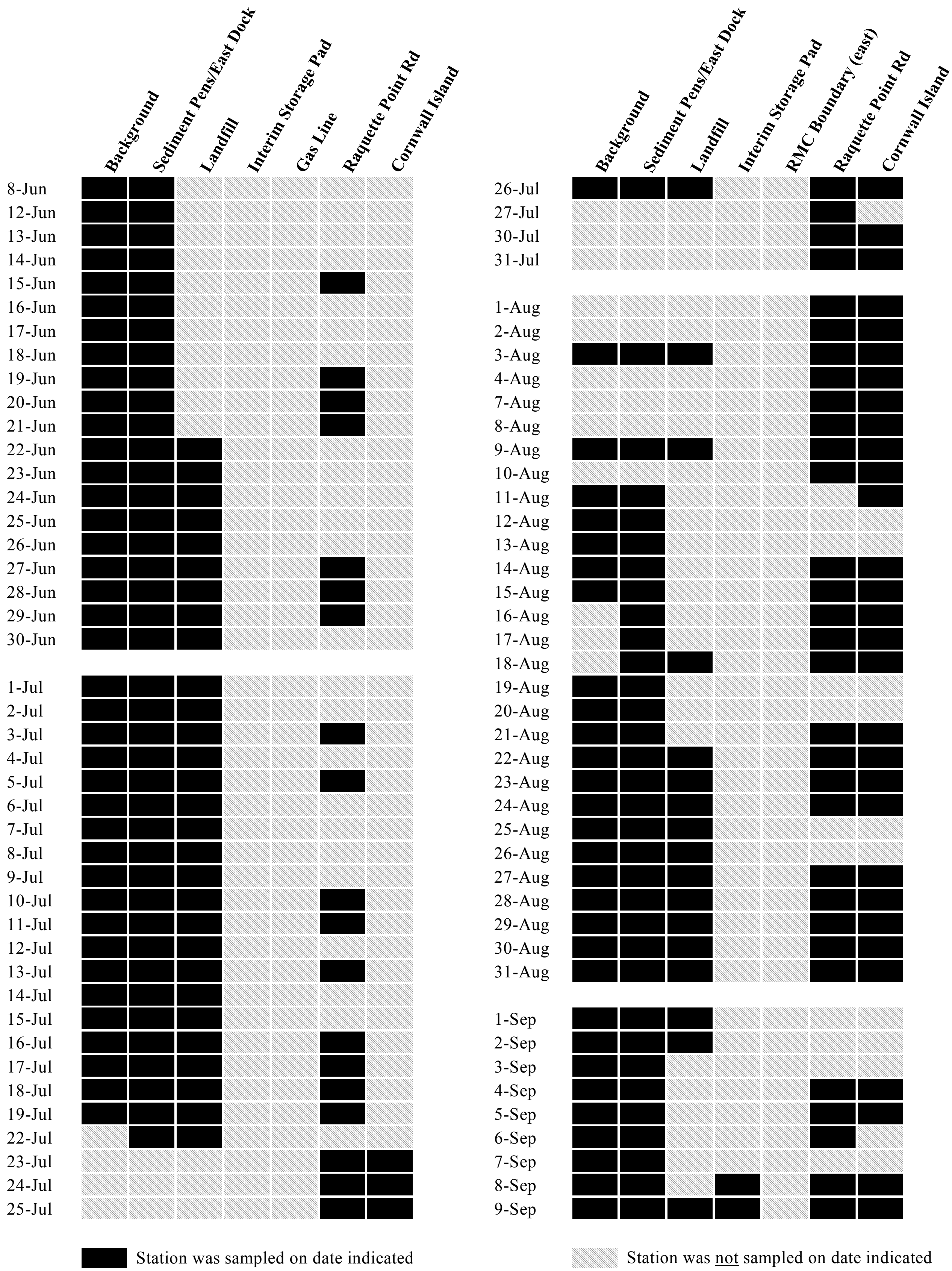


Figure 4-16
Boundary Air Sampling Schedule for PCBs

	Background	Sediment Pens/East Dock	Landfill	Interim Storage Pad	RMC Boundary (east)	Raquette Point Rd	Cornwall Island
10-Sep	■	■	░	■	░	■	■
11-Sep	■	■	░	■	░	░	░
12-Sep	■	■	░	■	░	■	■
13-Sep	■	■	■	■	░	■	■
14-Sep	■	■	░	░	░	■	■
15-Sep	■	■	░	■	░	░	░
16-Sep	■	■	░	■	░	░	░
17-Sep	■	■	░	■	░	■	■
18-Sep	■	■	░	■	░	■	■
19-Sep	■	■	░	■	░	■	■
20-Sep	■	■	■	■	░	■	■
21-Sep	■	■	░	■	░	■	■
22-Sep	■	■	░	■	░	░	░
23-Sep	■	■	░	■	░	░	░
24-Sep	■	■	░	■	░	■	■
25-Sep	■	■	░	■	░	■	■
26-Sep	░	■	░	░	░	■	■
27-Sep	░	■	░	░	░	■	■
28-Sep	■	■	■	■	░	■	■
29-Sep	░	■	░	░	░	░	░
30-Sep	░	■	░	░	░	░	░
1-Oct	░	■	░	░	░	■	■
2-Oct	░	■	░	░	░	■	■
3-Oct	░	■	░	░	░	■	■
4-Oct	░	■	░	░	░	░	░
5-Oct	░	■	░	░	░	░	░
6-Oct	░	■	░	░	░	░	░
7-Oct	■	■	■	■	░	░	░
8-Oct	░	■	░	░	░	░	░
9-Oct	░	■	░	░	░	░	░
10-Oct	░	■	░	░	░	░	■
11-Oct	■	■	■	■	■	■	■
12-Oct	░	■	░	░	■	■	■
13-Oct	░	■	░	░	■	░	░
14-Oct	░	■	░	░	■	░	░
15-Oct	░	■	░	░	■	■	■
16-Oct	░	■	░	░	■	░	░
17-Oct	░	■	░	░	■	■	■
18-Oct	░	■	░	░	■	■	░
19-Oct	░	■	░	░	■	■	░
20-Oct	░	■	░	░	■	░	░
21-Oct	░	■	░	░	■	░	░
22-Oct	░	■	░	░	■	■	■

	Background	Sediment Pens/East Dock	Landfill	Interim Storage Pad	RMC Boundary (east)	Raquette Point Rd	Cornwall Island
23-Oct	■	■	■	░	░	░	░
24-Oct	░	■	░	░	■	■	░
25-Oct	░	■	░	░	■	■	■
26-Oct	░	■	░	░	■	░	░
27-Oct	░	■	░	░	■	░	░
28-Oct	░	■	░	░	■	░	░
29-Oct	░	■	░	░	■	■	░
30-Oct	■	■	■	■	■	■	■
31-Oct	░	■	░	■	■	■	░
1-Nov	░	■	░	■	■	■	■
2-Nov	■	■	■	■	■	░	░
3-Nov	░	■	░	■	■	░	░
4-Nov	░	■	░	■	■	░	░
5-Nov	░	■	░	■	■	░	░
6-Nov	░	■	░	■	■	░	░
7-Nov	░	■	░	■	■	░	░
11-Nov	■	■	■	░	░	░	░
12-Nov	░	░	░	░	░	░	░
13-Nov	░	░	░	░	░	░	░
14-Nov	░	░	░	░	░	░	░
15-Nov	■	■	■	░	░	░	░
16-Nov	░	░	░	░	░	░	░
17-Nov	░	░	░	░	░	░	░
18-Nov	░	░	░	░	░	░	░
19-Nov	░	░	░	░	░	░	░
20-Nov	░	░	░	░	░	░	░
21-Nov	■	■	░	░	░	░	░

■ Station was sampled on date indicated

░ Station was <u>not</u> sampled on date indicated

Figure 4-16
Boundary Air Sampling Schedule for PCBs (continued)

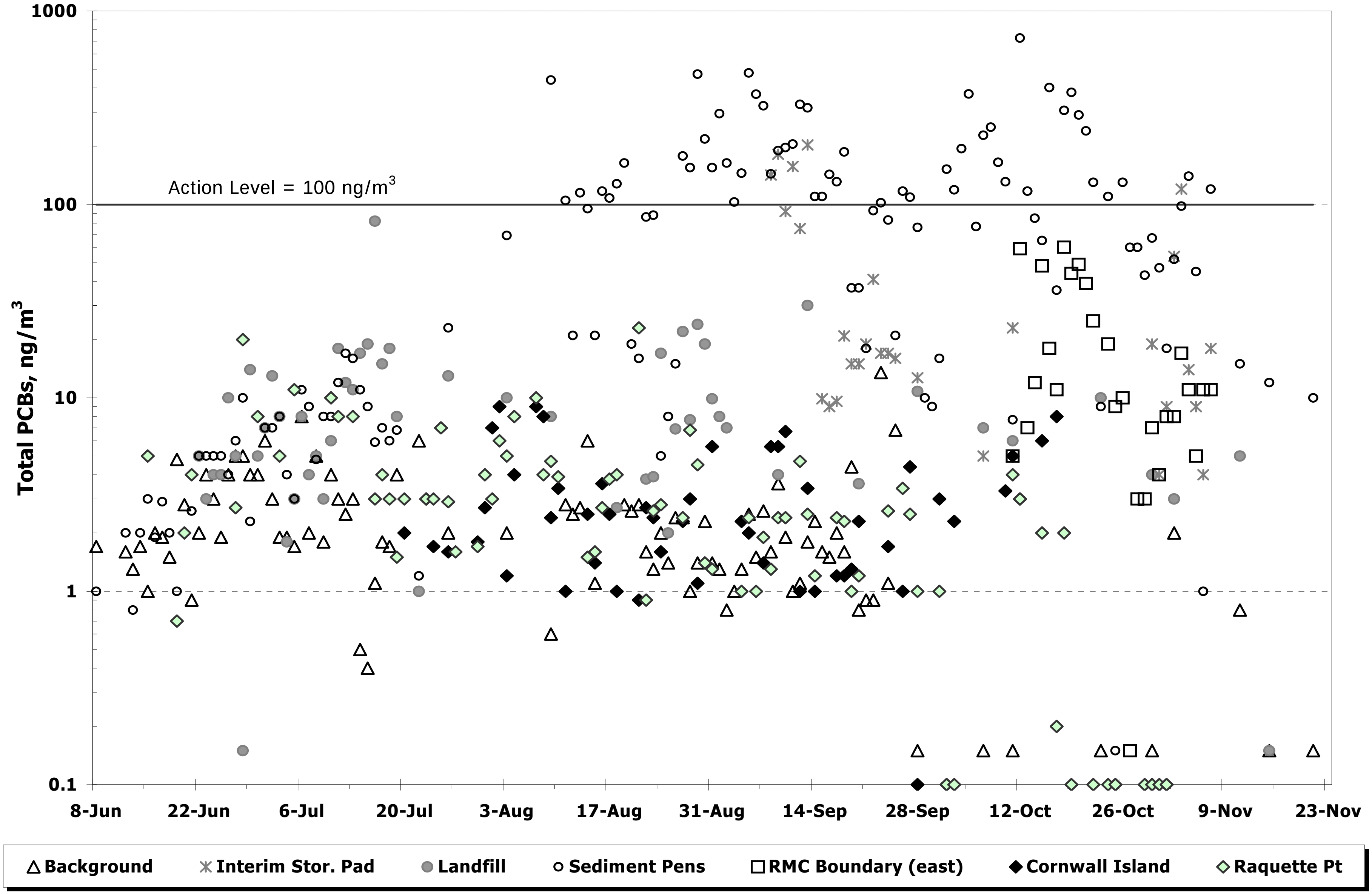


Figure 4-17
Boundary Air PCB Results – All Stations

PCBs were widely detected—essentially ubiquitous—with positive results reported in about 94% of the samples analyzed. The lowest percentage of PCB detections (85%) were reported in samples from the Raquette Point Road station on the SRMT Reserve. The percentage of samples with positive results collected from the onsite stations ranged from 93% (Background) to 100% (Interim Storage Pad). The relationship between the number of samples with detected PCBs and the total number of samples collected at the five stations with the largest number of boundary air samples is shown in Figure 4-18.

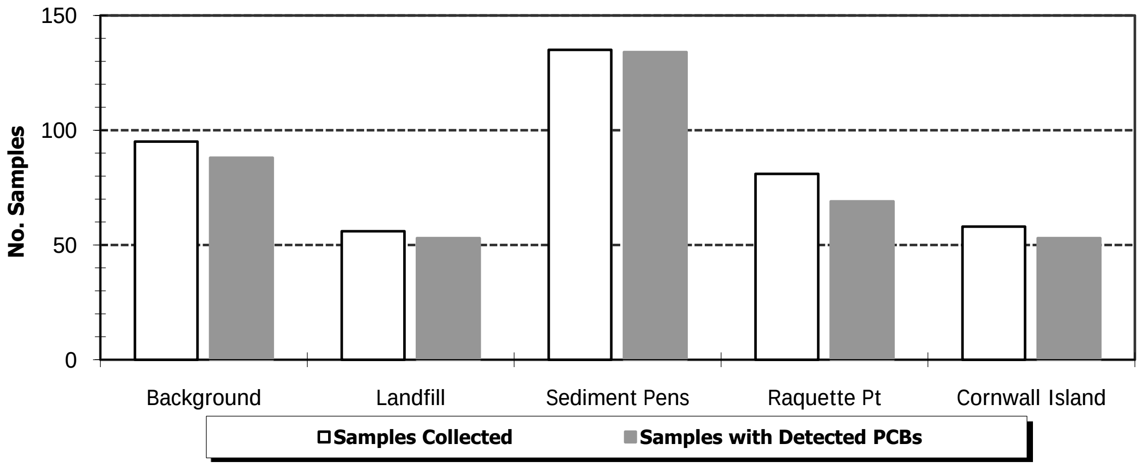


Figure 4-18
Relationship Between Air Samples Collected and Sample Results Indicating PCBs

The action level for PCBs in air was established in the EPA-approved EMP as 100 ng/m^3. As shown in Table 4-25, there were a large number of action level exceedances at station RRSASC, located immediately adjacent to the eastern edge of the sediment storage pens. These exceedances were attributed to the presence of numerous large stockpiles of contaminated sediment, a large portion of which consisted of sediment that had >500 ppm PCBs. Exceedances were also reported for samples from the station set up near the Interim Storage Pad, which was used for temporary storage of the >500 ppm material (after it was treated with Portland cement). No action level exceedances were identified in any of the offsite (SRMT Reserve) air monitoring stations. Further discussion of these exceedances is presented in the following subsection.

It is important to note that the action level for PCBs in air, 100 ng/m^3, was established at a level below any actual level of concern from a worker or community health perspective. The intent of the 100 ng/m^3 action level was to identify a threshold well below any health-based concentrations so that appropriate response or corrective measures could be implemented to mitigate the cause of the action level exceedances. This strategy met with mixed success, for the reasons detailed below, but a distinction must be drawn between action level exceedances and potential impacts on human health and environment. Action levels were exceeded on the site but these exceedances were still far below any levels that could be associated with any impact on human health or the environment.

Neither EPA nor DEC has regulations establishing health-based limits for air-borne exposures to PCBs as might occur during cleanup of contaminated sites. For this reason, the occupational exposure guidelines listed in Table 4-26 are generally used for development of monitoring programs during short-term remediation projects such as occurred in 2001 on the St. Lawrence River. The guidelines presented in Table 4-26 represent the criteria used by the Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH) in 2001.

Table 4-26
Exposure Criteria for Airborne PCBs

Standard	Aroclor 1242	Aroclor 1254	Source
NIOSH REL	1,000 ng/m^3	1,000 ng/m^3	Recommended exposure limit for 10-hr workday and 40-hr workweek
OSHA PEL TWA	1,000,000 ng/m^3	500,000 ng/m^3	8-hr time weighted average
ACGIH TLV	1,000,000 ng/m^3	500,000 ng/m^3	Threshold limit value for 8-hr workday and 40-hr workweek

Reference: http://www.osha.gov/SLTC/healthguidelines/

The 100 ng/m^3 action level used for the river remediation project is one-tenth of the lowest occupational exposure guideline, the NIOSH REL. The action level is 5,000 to 10,000 times lower than the other, higher guidelines.

PCB Exceedances in Air Samples

As stated above, exceedances of the PCB action level were identified in 2 of the onsite air monitoring stations: station RRSASC adjacent to the sediment pens and station RRIASC near the interim storage pad. Both of these stations lie within the property boundary of the RMC facility. There were no exceedances at the Cornwall Island stations or the Raquette Point Rd station that lie on the nearby SRMT Reserve. The magnitude, duration and source of these exceedances; the response measures undertaken by RMC toward mitigation; and the overall impact on the environment are examined below.

Table 4-27 presents summary statistics for the sample results exceeding the action level from the two onsite monitoring stations. The geometric mean concentration is based on all results exceeding 100 ng/m3 and shows that, *on average*, the exceedances were not significantly higher than the action level. The mean concentration also provides a more realistic value to use when considering the combined or overall impact of the elevated PCB concentrations in air.

Table 4-27
Onsite Action Level Exceedances for PCBs in Air

	Action Level Exceedances				
Station	**Start**	**End**	**#**	**Range (ng/m^3)**	**Mean (ng/m^3)**
SSASC *sediment pens*	8/9/01	11/7/01	53	102 – 724	158
IASC *interim storage pad*	9/8/01	11/3/01	5	120 – 203	187

The table also shows that exceedances at the sediment pens station began in August and continued through early November, a period of nearly 3 months. Figure 4-19 presents a graph of the total PCB concentrations in samples from the sediment pens monitoring station, and it can be seen that there were period of sustained exceedances as well as periods when exceedances occurred on an occasional or intermittent basis. Overall, however, the PCB concentrations during this time were mostly higher than 100 ng/m^3.

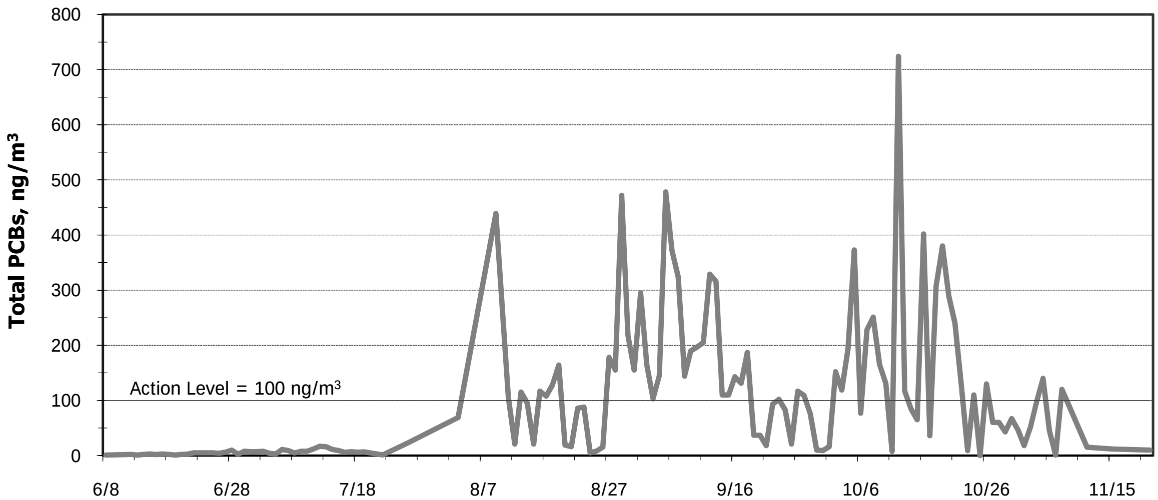


Figure 4-19
PCB Results for Air Monitoring Station RRSASC (Adjacent to Sediment Pens)

RMC attributed the exceedances at the SASC station to the presence, beginning in early August, of several stockpiles of sediment with >500 ppm PCBs. Around this time, the dredging was progressing at a relatively fast pace, and the pens were being filled almost as quickly as they could be emptied. As discussed in Section 3, the activities in the sediment storage area included a variety of sediment handling processes, including unloading of trucks, consolidating of material into stockpiles, stabilization through the addition and mixing of Portland cement, re-consolidation of the stabilized material to allow for curing, loading of trucks for transport to the onsite landfill and offsite disposal facility, and decontamination of equipment. These activities were required to complete the sediment processing phase of the project and could not be eliminated. Various mitigation measures, as outlined below, were taken to minimize the impact of these operations.

During the same time period (August, September, October), the weather was sunny, relatively hot, and dry, and the exposed sediment in the pens was drying out. There were only three modest rainfall events during this period (August 26, September 24-25, and October 22). As the sediment dried out it became susceptible to transport as dust, which is the most likely source of the exceedances. Transport of PCB-contaminated particulate matter to the monitoring station was facilitated at least in part by the extreme close proximity of the station to the active work area. Even minute quantities of such particulates reaching the station could account for the parts per trillion concentrations observed in the SASC sample results.

RMC went to great lengths to minimize dust emissions from the sediment storage area, using water trucks, water sprays, plastic coverings over stockpiles, and expanded "housekeeping" efforts by the Perras construction team to clean sediment from exposed surfaces. These efforts were only partially successful, as evidenced by the continuing pattern of exceedances. On September 5th, RMC transmitted to EPA a work plan for relocating five covered stockpiles with >500 ppm material from the sediment pens to the interim storage pad. The rationale for this relocation was the need to place the material in a more secure environment for long-term storage pending offsite shipment, and also to place the material beneath a more effective cover system to minimize the release of contaminated dust that was believed to be responsible for the action level exceedances at the SASC station.

The piles were relocated on September 8–13, 2001. The frequency and magnitude of exceedances at the SASC station declined for the next couple of weeks but then resumed in early October, when high-PCB-concentration stockpiles of sediment were once again present. At this point in time, RMC, in consultation with EPA, decided to establish a supplemental boundary air monitoring station (RRGASC) at the RMC property line near the International Bridge. This station was brought on-line on October 11 and was sampled on a daily basis for the next 27 days (i.e., until November 7, 2001). The results from this station, as well as corresponding results from the SASC (sediment pens) station is presented in Figure 4-20.

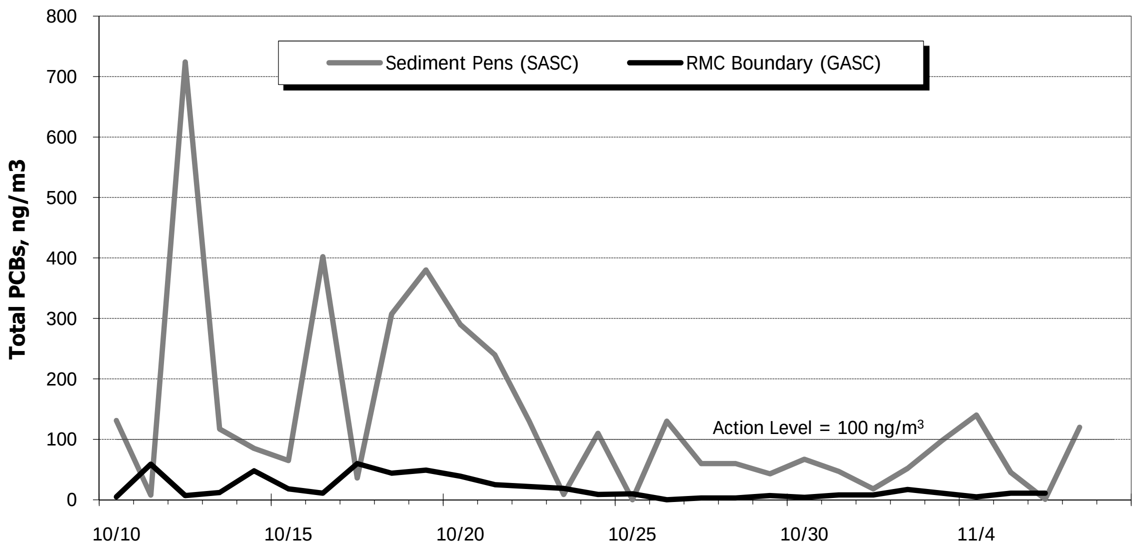


Figure 4-20
PCB Results from Sediment Pens and RMC Boundary Monitoring Stations

Results from the GASC station confirmed what earlier monitoring at the property boundary (based on collection of air samples using personal air pumps) had shown, namely that the airborne PCB contamination identified at the sediment pens monitoring station was a localized problem that did not translate into any significant offsite releases. There were no exceedances of the 100-ng/m^3 action level at the eastern boundary station, even when the concentration of PCBs at the SASC station reached the maximum recorded for the entire monitoring program. Additionally, monitoring results from the Raquette Point Rd and Cornwall Island stations did not exhibit detected PCB concentrations that were statistically different from background levels.

The other station with exceedances, RRIASC, was set up for the purpose of monitoring air quality downwind from the relocated >500 ppm PCB stockpiles at the interim storage pad. Exceedances at this station were recorded when the material was being placed on the pad (September 8–13, 2001) and then on a couple of occasions when the material was being removed for transport to the offsite disposal facility. These exceedances were of a short duration, and occurred despite the additional efforts expended to reduce dust generation. No exceedances were recorded at the eastern boundary location when the stockpiles were being removed.

In summary, RMC conducted an extensive program of airborne PCB monitoring, collecting and analyzing a total of 482 samples during the dredging, capping, sediment handling, and sheet pile removal activities. PCB action levels were exceeded at the monitoring station adjacent to the sediment pens; however, this problem was shown to be localized in extent and did not result in the offsite release of any concentrations above action levels. The overall conclusion from evaluation of the PCB air data is that the remediation project was completed with no measurable impact on any offsite or downwind receptors.

4.5.1.2 Airborne Particulate (PM_{10}) Monitoring

Boundary air monitoring for particulate dust was conducted during all activities involving the dredging, handling, transport or disposal of PCB-contaminated sediment. The monitoring was conducted at the three primary, onsite stations used for PCB monitoring: the background station, the monitoring station adjacent to the sediment pens, and the landfill station. Monitoring locations were shown in Figure 4-15.

Airborne particulate monitoring was conducted in accordance with the procedures described in the *EPA Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere* (EPA 1979). This method allows for the measurement of particulate matter having an aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) in ambient air, considered to represent respirable particulates. A high-volume critical flow sampler (Wedding and Associates 1992) was used to collect respirable particulates during each day of operations, with each sample representing a 24-hour composite.

The action level for particulate dust was established in the EPA-approved EMP as sustained readings of 150 $\mu g/m^3$ or greater above background. Background levels were measured at the onsite background monitoring station (designated BASP for particulate sampling). The action level was then determined on a daily basis by adding 150 to the background concentration.

A total of 476 PM_{10} samples were collected from the three boundary air monitoring stations between June 8 and November 21, 2001 (Table 4-28). Positive detections were reported in 91% of the samples. All of the data are plotted on Figure 4-21. Detected concentrations at the landfill and sediment pens monitoring stations were all well below the action levels, which varied with the level of PM_{10} in the background station. Data are presented in Appendix D.

Table 4-28
Summary of Boundary Air Sampling for Particulate Dust (PM10)

Location	Station	Start	End	# Samples	Detects	*Range ($\mu g/m^3$)*	Action Level Exceedances
Background	RRBASP	6/8/01	11/21/01	164	143	.58 – 59.9	--
Landfill	RRLASP	6/22/01	11/16/01	148	133	1U – 49.2	0
Sediment Pens	RRSASP	6/8/01	11/21/01	164	159	1.7 – 92.5	0
Total PM_{10} Samples		*6/8/01*	*11/21/01*	*476*	*435*	--	*0*

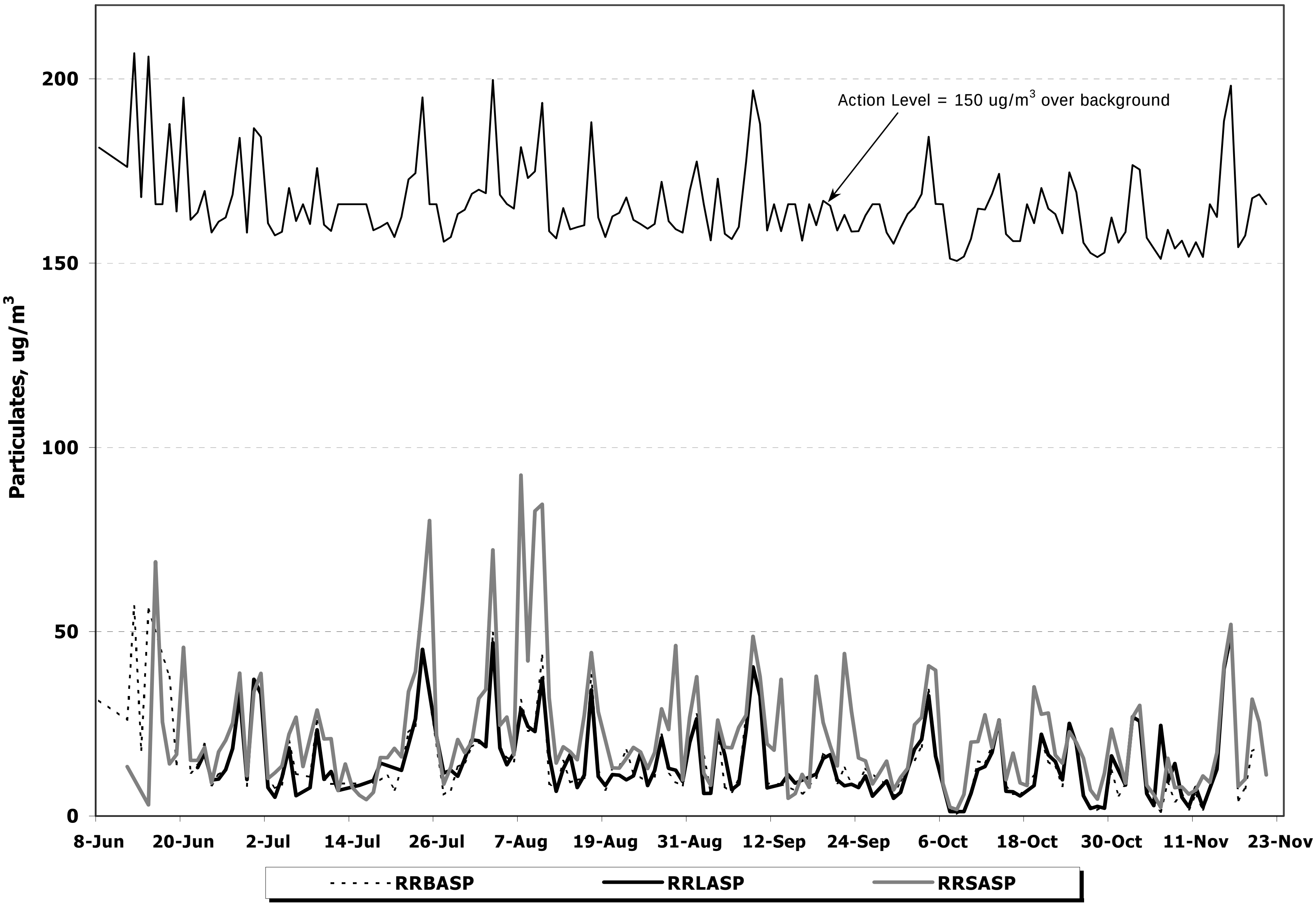


Figure 4-21
Boundary Air PM10 Results – All Data

In addition to monitoring, it is important to note that operational and engineering controls were used to reduce airborne dust emissions. These controls included limits on vehicle speeds, use of a water truck on gravel roads and water sprays during sediment handling operations, covering of stockpiled material and either shipment or offsite disposal as soon as it is logistically feasible to do so, and use of specialized stabilization methods and equipment.

Real-time dust monitoring was also conducted in all of the work areas where contaminated sediment was being handled. The results of this monitoring are discussed below.

4.5.1.3 Supplemental Air Sampling for VOCs

At the request of the SRMT, RMC undertook a month-long supplemental sampling effort to determine whether volatile organics were being released from the remediation area. Table 4-29 summarizes the sampling locations, dates and number of samples collected for this effort. A total of 96 samples were eventually collected and analyzed for VOCs. Sampling results are summarized in Appendix D.

All samples were collecting using Summa canisters and analyzed using method EPA Method TO-15. The selection of sampling locations and deployment of canisters was conducted jointly with the SRMT Environment Division representatives. Results from this effort were transmitted to SRMT as soon as they became available from the laboratory.

Table 4-29
Supplemental Air Sampling for VOCs

Location	Station	Start	End	# Samples
SRMT Reserve	Cornwall Island - Dean Point	7/14/01	8/17/01	15
	Cornwall Island - Int. Bridge	7/17/01	7/25/01	10
	Cornwall Island - Roundpoint	7/14/01	8/17/01	15
	Cornwall Island - Sharrow	7/14/01	8/17/01	15
	Raquette Point Road	7/14/01	8/17/01	15
RMC site	Sheet pile Wall (Sta. 30+00)	7/17/01	8/17/01	13
	River Dewatering Beds	7/19/01	8/16/01	9
	Sediment Pens	7/18/01	8/16/01	4
	Total VOC Samples	*7/14/01*	*8/17/01*	*96*

Several VOCs were detected, and a large number of samples contained low levels of common laboratory contaminants, including acetone and methylene chloride. Several samples also contained hexane, which was used extensively in the decontamination of field sampling equipment at the site. Detected VOCs that were not attributed to either lab or field contamination are shown in Table 4-30.

None of the detected concentrations appear to be at levels considered to represent a potential health risk, based on a comparison to OSHA PELs. In addition, none of the volatile organics detected were derived from the contaminated sediment that was being removed from the St. Lawrence River.

Table 4-30
Detected VOCs in Air Samples

Sampling Location	Date	Detected Compound	Result (ppbv)	OSHA PEL (ppb)
Cornwall Island - Sharrow	7/25/01	1,4-Dioxane	31	100,000
Sheet pile Wall (Sta. 30+00)	7/25/01	2-Propanol	29	100,000
Cornwall Island - Dean Point	7/14/01	Bromomethane	10	20,000
Cornwall Island - Dean Point	7/14/01	Dichlorodifluoromethane	10	1,000,000
Sheet pile Wall (Sta. 30+00)	8/2/01	Ethyl acetate	6	400,000
Cornwall Island - Dean Point	8/2/01	Ethyl acetate	5	
SEDIMENT PEN	8/16/01	Toluene	32	100,000
River Dewatering Beds	7/19/01	Toluene	11	
River Dewatering Beds	8/16/01	Toluene	8	
Cornwall Island - Roundpoint	8/17/01	Toluene	8	
Raquette Point Road	8/17/01	Toluene	6	

Note: OSHA Permissible Exposure Limits obtained from http://www.osha.gov/SLTC/healthguidelines/

4.5.1.4 Area-Wide Air and Ambient Dust Monitoring

Area-wide air and ambient dust monitoring were conducted to monitor the working environment for personnel engaged in the dredging, sediment handling and landfill operations. This monitoring included sampling and analysis for PCBs and PAHs, and measurement of ambient dust levels. Results are summarized below.

Area-Wide Air Monitoring

Area –wide air monitoring was conducted using personal air sampling equipment mounted in the cab of a derrick, on a fence post near the work zone, or in other configurations near areas where contaminated sediment was being handled. This type of monitoring is not considered personal air sampling as the equipment is not placed on a worker and therefore does not reflect an actual work-day exposure for an individual. The area monitoring samples were used in support of the personal air sampling that was conducted and served primarily as a means of verifying that the health and safety protocols were providing adequate protection to site workers.

A large number of area-wide air monitoring samples were collected from a variety of stations. Table 4-31 lists the monitoring stations and the type and number of samples collected at each station.

Table 4-31
Area-wide Air Monitoring Summary

Station	Location/Description	# Samples PCB	# Samples PAH
RRR4PC	Ryba#4 dredge barge (operator's cab)	10	--
RRCOPC	Comanche dredge barge (operator's cab)	23	12
RRCAPC	CAT350 (operator's cab)	4	2
RREDPC	East Dock	36	12
RRP13C	Sediment pen #13	2	--
RRP15C	Sediment pen #15	5	--
RRP16C	sediment pen #16	5	--
RRSPAC	Sediment pens (general—not pen specific)	12	6
RRISAC	Interim storage pad area	7	--
RRRB03	River dewatering beds	75	39
RRAC2C	Air gate #2	15	15
RRLF1C	Landfill	95	48
RRRWPC	Rock washing station	1	--
	Total Number of Samples	*290*	*134*

Area-wide monitoring results are presented in Appendix D. There were no exceedances of OSHA PELs. Samples collected at air gate #2 indicate that there was no volatilization of PCBs or PAHs from these devices (the air space over the air gates was also monitored for 2 weeks with a volatile organics detector, and no VOCs were detected). The area-wide monitoring data support the conclusions derived from analysis of the boundary air sampling results that the remediation project did not result in the release of any significant levels of contamination to the air.

Ambient Dust Monitoring

Ambient dust monitoring was conducted from late June through mid-November. Monitoring was conducted using an MIE personal DataRAM instrument that measured airborne dust particles over a specified time interval and reported an ambient dust concentration in $\mu g/m^3$. Action levels for dust monitoring were derived from the DEC's Division Technical and Administrative Guidance Memorandum – *Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites* (TAGM #4031).

DEC's guidance memorandum identifies an action level of 150 $\mu g/m^3$. If the particulate (dust) levels are greater than 150 $\mu g/m^3$, the upwind background levels must be immediately measured. If the working site particulate level are greater than 100 $\mu g/m^3$ above the background level, then work must be stopped and additional dust suppression efforts must be implemented. If the action level of 150 $\mu g/m^3$ is exceeded over a 24-hour averaging time period, the DEC was to be notified.

A summary of the ambient dust monitoring activities is presented in Table 4-32. Monitoring results are presented in Appendix D.

Table 4-32
Ambient Dust Monitoring Summary

Location/Description	Start	End	# Measurements
Background station on Haverstock Road	7/7/01	11/17/01	457
East Dock	6/18/01	11/17/01	469
East of Sediment Pens	6/28/01	8/24/01	32
Hot Metal Rd east/southeast of sediment pens	7/22/01	11/17/01	402
East of sediment pen 15	8/22/01	9/15/01	72
East of sediment pen 16	8/22/01	9/15/01	72
East of sediment pen 13	8/22/01	9/15/01	72
Landfill	6/21/01	11/15/01	498
River drying beds	7/20/01	11/17/01	399
Total ambient dust measurements	*6/18/01*	*11/17/01*	*2,473*

There were some problems related to ambient dust, particularly during the initial period of work related to the offloading and mixing of Portland cement for stabilization of wet sediment. Portland cement is a powder and even with extreme care it is difficult to unload and use without generating some dust. RMC notified DEC in correspondence dated July 11, 2001 that the preliminary dust monitoring data from the stabilization activities at the landfill had identified a potential exceedance of the 150µg/m^3 action level.

As stated in its correspondence to DEC, RMC undertook a number of steps to mitigate the dust emissions through the use of specialized equipment and revised procedures for both the transfer of cement and stabilization of sediment. The greatest potential impact from the ambient dust was on site workers, and RMC also implemented a number of operational and engineering controls to minimize these impacts. The boundary air station PM_{10} data discussed above showed that there were no exceedances of the particulate action levels at the property boundaries, indicating that the ambient dust problems were localized in extent and had no impact on down-wind receptors.

4.5.1.5 Personnel Air Monitoring

An extensive program of personnel air monitoring was completed involving workers in all work areas involving the handling of contaminated sediment. Samples were collected and analyzed for PCBs, PAHs, silica, respirable dust, and total dust. These data, used to verify adequate respiratory protection was being used for site workers, are presented in Appendix D. There were no exceedances of OSHA PELs or other appropriate occupational exposure guidelines.

4.6 SCHEDULE OF ENVIRONMENTAL MONITORING

Figure 4-22 presents a summary schedule showing the duration of all environmental monitoring activities completed for the project.

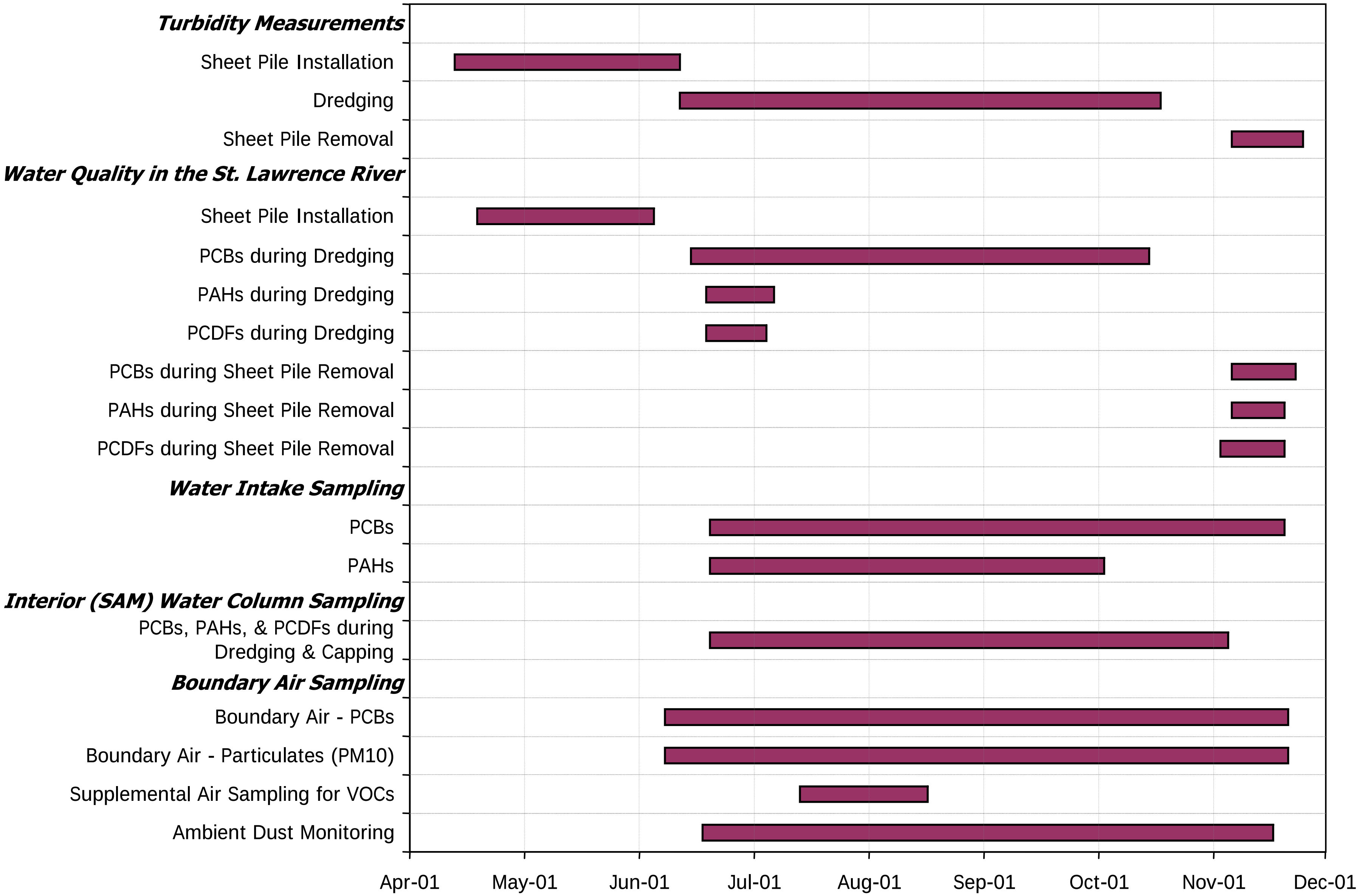


Figure 4-22
Schedule of Environmental Monitoring Activities

5.0 DEMOBILIZATION

Demobilization activities began once the dredging was completed in mid-October. The activities entailed the dismantling and removal of structures or systems, decontamination of equipment and materials, and the return of cleaned equipment back to its point of origin (e.g., leasing agency, subcontractor's yard). Photographs of demobilization activities are presented in Appendix F.

5.1 REMOVAL OF CONTAINMENT SYSTEMS

Removal of sheet pile wall, silt curtains, and air gates was completed using similar methods to those used for installation. The timing of the removal activities was dependent on the purpose of the system and its role in completed or on-going activities, and in some cases (e.g., removal of sheet pile wall) was based on the results of environmental monitoring.

5.1.1 Silt Curtains

Removal of the silt curtains and associated anchor posts surrounding Area C was completed on September 17, 2001; the Area B curtain and anchor posts were removed on October 18, 2001. The 56 H-beams used for anchor posts were placed on barges and taken to the East Dock for unloading and transfer to the Sediment Storage Area. The anchor posts were then deconned and transferred to the Laydown yard for storage after wipe sampling confirmed they were clean. A 250-ft portion of the silt curtain was saved and stored along the shoreline of Area C. The balance of the curtain was loaded into trucks and taken to the on-site landfill for disposal.

5.1.2 Air Gates

Air gates G-2 and G-3 were removed along with the Area C silt curtain in mid-September. Gate G-4 was removed when the Area B silt curtain was taken out. Air gate components were deconned moved to storage in the Laydown yard.

5.1.3 Sheet Pile Wall

Removal of the sheet pile wall began on the 6th of November with creation of the eastern opening in the sheet pile wall. Openings were created on the western end of the wall and in the central portion of the wall over the next few days. The openings were gradually enlarged while monitoring continued and once it was demonstrated there was no impact on water quality in the St. Lawrence River the pace of removal activities quickened considerably. Removal of the wall was completed on November 25, 2001.

The 208 king piles, 2,243 sheets, and assorted walers and bracing were pulled using the same equipment that was used to install them. The main difference was that most of the king piles were sheared off after initial attempts to hammer or vibrate the piles back out of the sediment were unsuccessful. Counting the H-beam anchor posts used to anchor the silt curtains, only about 20 % of the king piles could be vibrated out of the river bottom. The rest were sheared off.

A hydraulic shearing device, rigged to the Cat 350, was used to shear the king piles. The device was capable of shearing high tensile strength steel piles with 8,500 to 9,500 psi hydraulic pressure; cutting time was about 3-5 seconds per cut. Working in tandem with the Comanche derrick barge, the Comanche would hook onto the king pile and the Cat 350 would cut it off. The Comanche then placed the king pile into an adjacent material barge. It was not necessary to shear any of the sheeting. The sheets were vibrated out and placed into a material barge for transport.

The H-beam king piles and steel sheets were brought to the East Dock, unloaded onto flat-bed trucks, and taken to the Sediment Storage Area for decontamination. Approximately 60% of the steel was decontaminated prior to winter shut-down in December 2001. Following decontamination, wipe samples were collected on a random basis to verify that the decontamination was successful. The cleaned steel was then taken to the Laydown yard for storage pending resale or recycling.

5.2 DECONTAMINATION OF EQUIPMENT AND MATERIALS

Equipment and materials were decontaminated using high-pressure washers spraying hot water. Both Hotsys (3,000 – 5,000 psi) and a large truck-mounted National Liquid Blasting (20,000 psi) were used. Surfaces were manually scrubbed with steel brushes or other tools when necessary. Biodegradable soap was also used where needed. All equipment used for the dredging, handling, or transport of contaminated sediment was decontaminated. All materials that were to be either released from the site (e.g., steel being bought back by the vendor) or placed in storage for possible future use were also decontaminated.

Decontamination activities took place within or on the dredging barges, in the Sediment Storage Area or at the RMC decon pad (located near the river construction gate on the eastern side of the plant). All spent decon water was collected and transported to the onsite water treatment plant for treatment. An agreement was obtained through the RMC/Alcoa SPDES permit with NYSDEC to allow for the treatment of this water.

All equipment was visibly inspected after deconning to verify removal of visible contamination. Wipe tests were conducted on randomly selected surfaces of each piece of equipment in accordance with Alcoa procedures, which are based on 40 CFR Part 761 requirements for decontamination of PCB-contaminated surfaces. Wipe samples on the sheet pile steel also were conducted at random, at a frequency of one sample every other day. Wipe sample test results had to demonstrate that contamination was less than 10 µg per 100 cm^2 of surface to be considered clean. Multiple decontamination passes were required on most of the barges to satisfy the wipe sample criterion. Once the equipment or material was considered clean, it was released from the site in accordance with Alcoa procedures.

5.3 DECONTAMINATION/REMOVAL OF ON-SHORE FACILITIES AND SITE RESTORATION

The Sediment Storage Area was cleaned following removal of the final sediment stockpiles in November. The Jersey barriers were decontaminated and removed for use elsewhere on the RMC site. The asphalt pad was pressure washed and core sampled (four locations) to verify it had <50 ppm PCBs. The water treatment plant was decontaminated and wipe sampled. The Baker tanks were returned to the vendor. Large treatment units were retained for resale; small items such as pumps and hoses, were turned over (after deconning) for use by Alcoa.

The Sediment Storage Area was excavated in 2002 and placed in the onsite landfill for disposal and the site was graded, seeded and mulched. The loop road that passed around the Sediment Storage Area and led down to the East Dock will remain for future access to the dock.

The East Dock extension was removed in late September. The king piles were sheared off in late October. The East Dock was decontaminated in early December following completion of the sheet pile wall removal. The dock will remain in place but accessible only to RMC/Alcoa personnel.

5.4 LANDFILL

Following placement and compaction of the final lift of sediment, the landfill was shaped to the design grade and temporary measures were put into place for control of water run-off (e.g., silt fencing, ditching). The surface was hydroseeded. Construction of the final cap and cover system occurred in 2002.

6.0 SUCCESS OF REMEDIATION

This section discusses the effectiveness of the 2001 sediment removal efforts with regard to attainment of the cleanup goals and compliance with the requirements specified in the regulatory drivers for the project, including the 1989 106 Order, 1993 ROD, and 1998 ROD Amendment.

6.1 VERIFICATION SAMPLING RESULTS

Post-dredging verification sampling for PCBs was conducted in each cell that was dredged. The process of verification sampling was focused on PCBs as this class of compounds was the principal driver for the remediation. The process was intended to follow the flow sheet logic included in the Remedial Action Work Plan (Bechtel, 2001), which established how the PCB sampling results would be used to determine if a sufficient reduction in contaminant concentrations had occurred. This determination defined the level of effort and measurable improvement required to continue dredging in areas that did not meet cleanup goals after dredging to design depth.

As discussed in Section 3, considerably more dredging effort was required than originally planned, due primarily to the difficulties in attaining the sediment cleanup goals for PCBs. In addition to greater persistence, the PCB contamination in cells with multiple dredge passes exhibited much greater variability than expected. This variability resulted in unpredictable concentration trends that did not follow the path envisioned with the flow sheet logic. Persistence, variability, and unpredictability in the sediment PCB concentrations resulted in many more dredge passes than predicted, a greatly expanded data base of verification sampling results, and a group of cells that did not fit neatly into any of the categories of the flow sheet logic.

6.1.1 Remediation of PCBs

Evaluation of the success of the remediation with regard to PCBs is based on the final verification sample result from each of the 268 dredge cells. This final data set consists of 86 immunoassay results and 182 laboratory PCB results (86+182=268). The complete data set for PCBs in sediment consists of 532 immunoassay analyses and 566 lab analyses; the additional analyses (i.e., above and beyond the 268 analyses) were derived from the large number of cells that required multiple dredge passes in an attempt to achieve the project cleanup objectives. The complete data set allows for the evaluation of dredging performance and provides insight into both the significant level of effort that went into cleaning up the site and the complexity of the sediment remediation process.

The status of all 268 dredge cells at the conclusion of the 2001 dredging program is shown in Table 6-1. The distribution of final verification results within each Evaluation Area (by final PCB concentration (or concentration range) is shown in Table 6-2. Final verification results for PCBs are also plotted on Figures 6-1 (*Evaluation Area 1*) and 6-2 (*Evaluation Areas 2 and 3*).

Table 6-1
Final Status of Dredge Cells, by Concentration or Remediation Category

EVALUATION AREA 1		EVALUATION AREA 2							EVALUATION AREA 3					
<1 ppm	**1-2 ppm**	**<1 ppm**			**1-2 ppm**	**MFE**	**2-5 ppm**	**Capped**	**<1 ppm**		**1-2 ppm**	**MFE**	**2-5 ppm**	**Capped**
A-1 A-2 A-3 A-5 A-6 A-7 A-8 A-9 A-11 A-12 A-13 A-14 A-18 A-19 A-20 A-21 A-22 A-23 A-24 A-25 A-27 A-28 A-29 A-30 A-31 A-33 A-34 A-35 B-2	A-4 A-10 A-15 A-16 A-17 A-26 A-32	B-1 C-8 C-10 C-11 C-14 C-15 C-16 C-25 C-26 C-29 C-30 C-32 C-34 C-50 C-51 C-52 C-53 C-66 C-67 C-69 C-70 C-80 C-81 C-83 C-87 C-88 D-18 D-19 D-20 D-21 D-22 D-23 D-24 D-25 D-26	D-27 D-28 D-29 D-44 D-45 D-46 D-47 D-48 D-49 D-50 D-51 D-52 D-53 D-54 D-55 D-56 D-71 D-72 D-73 D-74 D-75 D-78 D-79 D-81 D-82 D-83 D-92 D-93 D-94 D-95 D-96 D-97	D-98 D-108 D-113 D-115 D-120 D-124 D-126 D-127 D-128 D-129 D-131 D-132 D-133 D-134 D-135 D-136 D-137 D-138 D-139 D-140	C-12 C-33 C-47 C-48 C-49 C-68 C-82 C-85 C-91 D-17 D-43 D-76 D-77 D-80 D-107 D-110 D-111 D-114 D-117 D-122 D-125	C-9 C-84 D-109 D-118 D-119 D-121 D-130	C-13 C-28 C-31 C-71 C-79 C-89 C-90 D-112 D-123	C-27 C-43 C-44 C-45 C-46 C-62 C-63 C-64 C-65 C-76 C-77 C-78	C-1 C-2 C-4 C-5 C-6 C-18 C-20 C-22 C-35 C-36 C-38 C-54 C-56 C-57 C-59 C-72 D-1 D-2 D-3 D-4 D-5 D-6 D-7 D-8 D-9 D-10 D-11 D-12 D-13 D-14 D-16 D-30 D-31 D-32 D-33	D-34 D-35 D-36 D-37 D-38 D-39 D-40 D-42 D-57 D-58 D-59 D-60 D-61 D-62 D-63 D-64 D-65 D-66 D-67 D-68 D-69 D-70 D-86 D-87 D-88 D-89 D-90 D-91 D-100 D-101 D-104 D-105 D-106 D-116	C-3 C-7 C-17 C-19 C-21 C-23 C-39 C-40 C-55 C-58 C-74 D-15 D-41 D-84 D-85 D-102	C-37 C-61 D-99 D-103	C-24 C-60 C-73 C-75	C-41 C-42 C-86
29 cells	***7 cells***	***87 cells***			***21 cells***	***7 cells***	***9 cells***	***12 cells***	***69 cells***		***16 cells***	***4 cells***	***4 cells***	***3 cells***

NOTE: Capped cells include 1 cell w/ 1-2 ppm, 1 cell w/ 2-5 ppm, & 1 cell w/ 5-10 ppm MFE cells include 6 cells w/ 1-2 ppm, 2 cells w/ 2-5 ppm, & 3 cells w/ 5-10 ppm

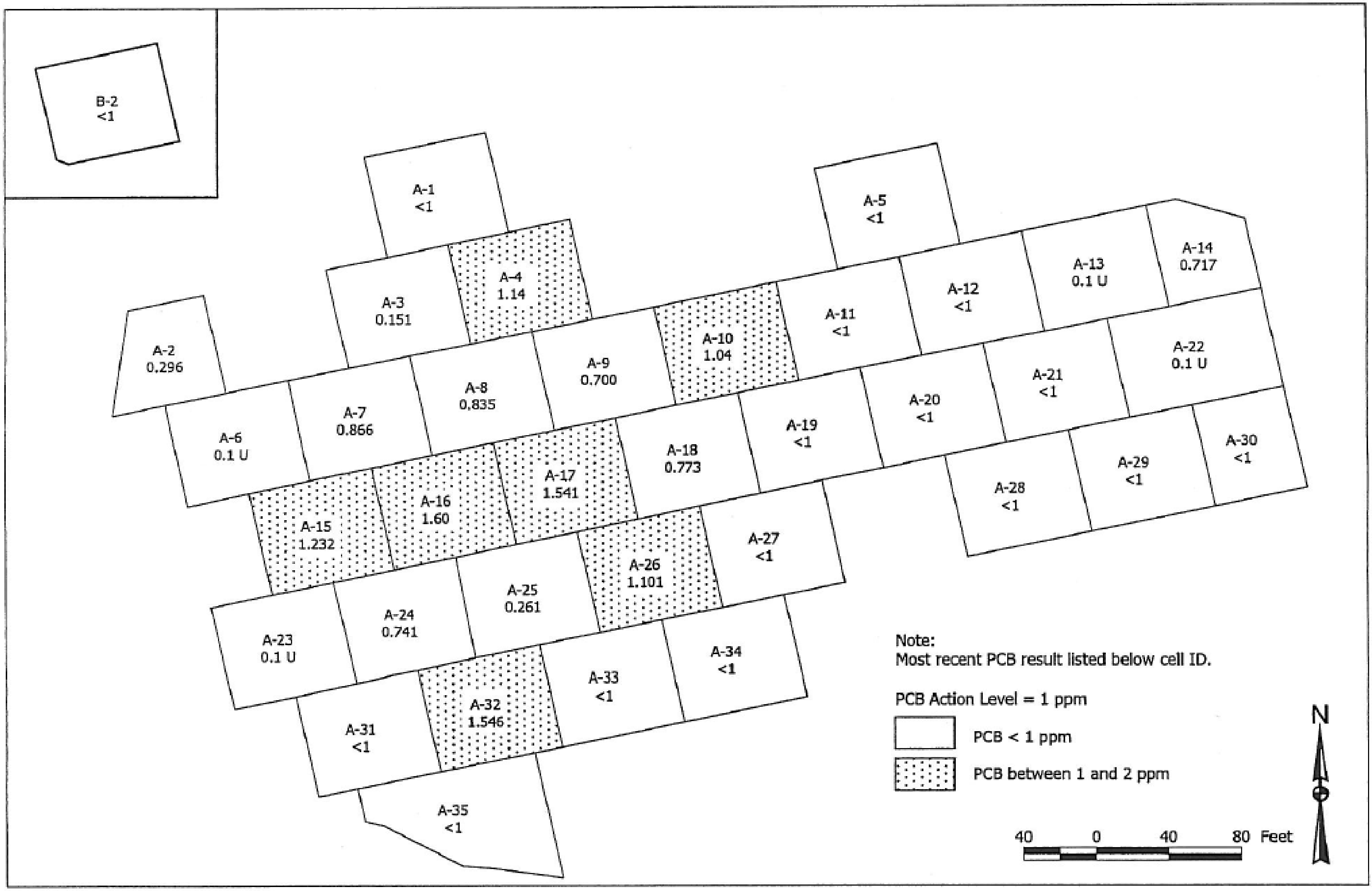


Figure 6-1
PCBs in Area 1

Figure 6-2
PCBs in Area 2 and 3

Table 6-2
Sediment Verification Sampling Results for PCBs: All Cells

	Eval. Area 1		Eval. Area 2			Eval. Area 3		
	1A	**1B**	**2B**	**2C**	**2D**	**3C**	**3D**	***Totals***
PCBs <1 ppm	28	1	1	25	61	16	53	***185***
PCBs between 1 and 2 ppm	7	--	--	10	16	11	7	***51***
PCBs between 2 and 5 ppm	--	--	--	8	3	5	--	***16***
PCBs between 5 and 10 ppm	--	--	--	3	--	1	--	***4***
PCBs >10 ppm	--	--	--	9	--	3	--	***12***
Total number of cells	*35*	*1*	*1*	*55*	*80*	*36*	*60*	***268***

NOTE: All 12 of the cells with >10 ppm PCBs were capped at the conclusion go the 2001 construction season, as were one cell in each of the following categories: PCBs between 1 and 2 ppm, PCBs between 2 and 5 ppm, and PCBs between 5 and 10 ppm.

Figure 6-3 presents a comparison of the pre- and post-dredging distribution of sediment sampling results (pre-dredging data were obtained from the 0-8 inch depth interval only). The comparison is complicated by the fact that the majority of the pre-dredging sampling results were based on immunoassay methods which give concentration ranges rather than a single value. To compensate for this limitation, the post-dredging verification data were aggregated into similar concentration ranges for the comparison. Another limitation to the comparison of pre- and post-dredging sediment data is related to the much smaller number of pre-dredging samples from the more highly contaminated portions of the site (Areas 2C and 3C), which biases the pre-dredging data set toward lower concentrations.

Nearly 70 percent (185) of the cells were remediated to less than 1 ppm; prior to dredging, fewer than 20 percent of the sampling locations had concentrations of <1 ppm (0-8 inch depth interval). Another 51 cells, representing 19 percent of the total, were remediated to less than 2 ppm. A major contrast can be seen in the proportion of cells with greater than 10 ppm: prior to dredging, nearly 30 percent of the sampling locations had PCB concentrations >10 ppm; in the final verification samples, this category declined to 4 percent, all of which were covered with the interim cap.

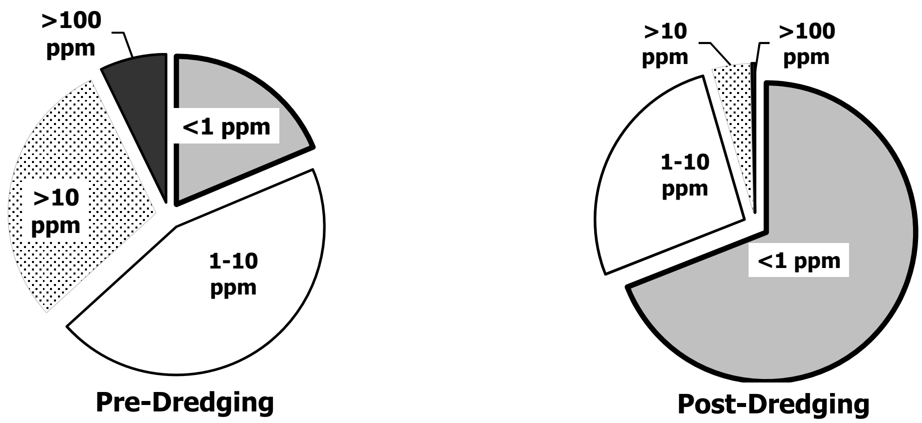


Figure 6-3
Comparison of Sediment PCB Results (0-8 inch depth); Pre- and Post-dredging

The comparison shows that dredging accomplished a significant reduction in the overall levels of PCB contamination at the site. Of particular significance is the reduction on the high end of the concentration ranges, with PCB concentrations >100 ppm. Prior to dredging, 7 percent of the locations had concentrations >100 ppm, including several greater than 1,000 ppm (the *hot spots*, discussed below). Only one of the final verification samples had greater than 100 ppm (C-76, which was eventually capped).

Figure 6-4 presents summary statistics and distribution plots for the 2001 post-remediation PCB sediment data (including capped cells). The statistical data for PCBs are presented for comparison to analyses presented below in the evaluation of PAH and PCDF verification results.

Table 6-3 presents a comparison of the area-wide, pre- and post-dredging PCB concentrations for each of the 3 Evaluation Areas (the capped cells in Area C were excluded from the post-dredging averages). Also shown is the calculated percent reduction in concentrations, within each Evaluation Area and across the entire site. Average PCB concentrations in the 3 evaluation areas ranged from 0.6 to 1.4, well below the 5 ppm area-wide criterion specified in the *Final Design* for a determination that remediation requirements were complete. Site-wide, the average PCB concentrations were reduced from 59.1 to 0.8 ppm, corresponding to a 99 percent reduction in sediment PCB concentrations.

Table 6-3
Percent Reduction in PCB Concentrations for Evaluation Areas

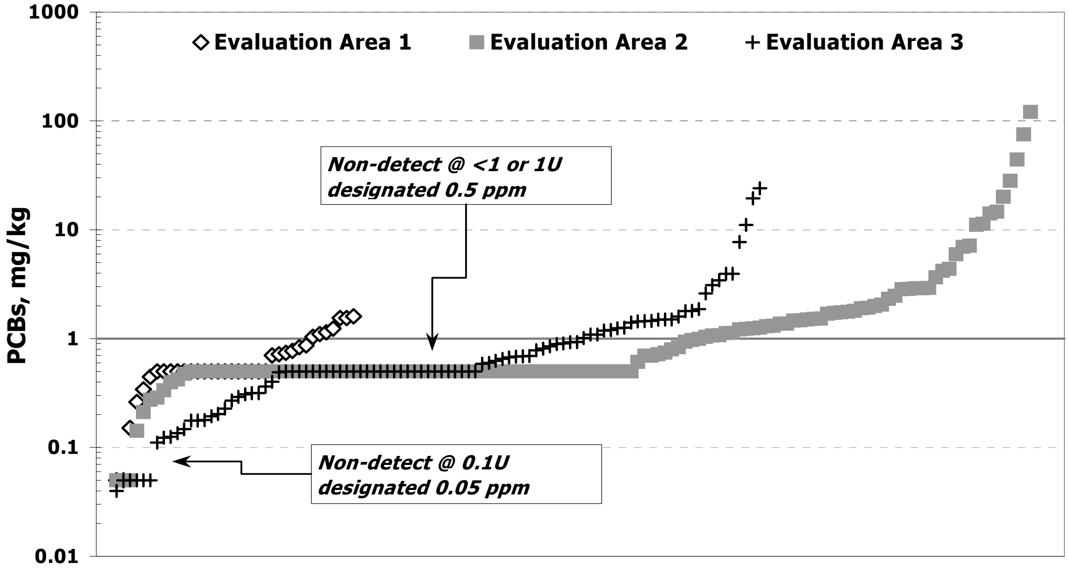
	Evaluation Area			**Site-Wide Average**
	1	**2**	**3**	
Pre-Dredging PCB Concentration, ppm	10.1	65.1	82	59.1
Post-Dredging PCB Concentration, ppm	0.6	1.4	0.5	0.8
Percent Reduction	***93.8%***	***97.9%***	***99.4%***	***98.6%***

Estimates of PCB mass removal were presented in Section 3.3. These estimates indicated that dredging removed approximately 20,200 lbs of PCBs from the St. Lawrence River. The disposition of this contaminant mass is summarized in Table 6-4.

Table 6-4
PCB Mass Removal from the St. Lawrence River

Final Disposition of Sediment	Weight of PCBs, lbs
On-site Landfill	1,648
Offsite disposal (≥50 ppm PCBs)	3,395
Treatment w/ offsite disposal (>500 ppm PCBs)	15,154
Total mass of PCBs removed from river	*20,197*

Figure 6-5 presents a graph of the estimated PCB mass removal per dredge pass. The chart shows that the bulk of the mass removal efforts were accomplished in the first three dredge passes, but that continued dredging did accomplish additional mass removal.



Evaluation Area 1		Evaluation Area 2		Evaluation Area 3	
Mean	0.656	Mean	3.487	Mean	1.408
Standard Error	0.064	Standard Error	1.111	Standard Error	0.341
Median	0.5	Median	0.5	Median	0.5
Standard Deviation	0.385	Standard Deviation	12.957	Standard Deviation	3.338
Sample Variance	0.148	Sample Variance	167.886	Sample Variance	11.143
Kurtosis	0.811	Kurtosis	56.572	Kurtosis	30.897
Skewness	1.040	Skewness	7.117	Skewness	5.350
Range	1.55	Range	120.407	Range	23.972
Minimum	0.05	Minimum	0.05	Minimum	0.04
Maximum	1.6	Maximum	120.457	Maximum	24.012
Sum	23.631	Sum	474.29	Sum	135.209
Count	36	Count	136	Count	96
Confidence Level (95.0%)	0.130	Confidence Level (95.0%)	2.197	Confidence Level (95.0%)	0.676

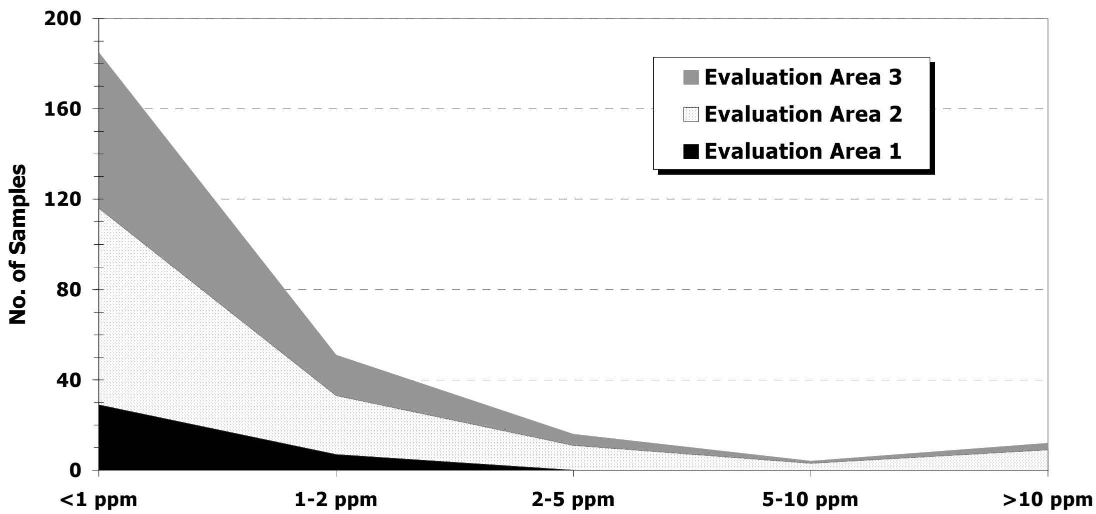


Figure 6-4
Distribution and Summary Statistics for Sediment PCBs

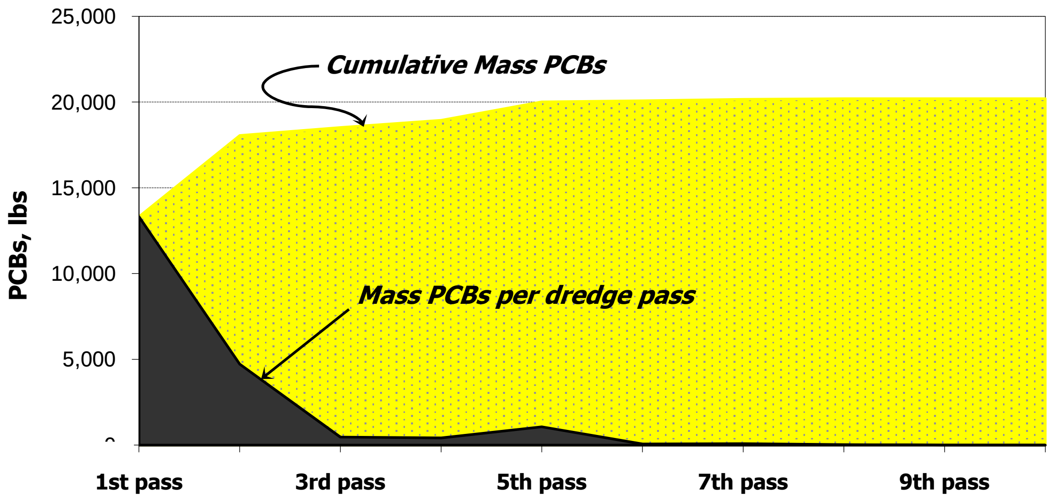


Figure 6-5: PCB Mass Removed per Dredge Pass

As shown in Tables 6-1 and 6-2, PCB cleanup goals were not achieved in some of the dredge cells. The following subsections evaluate the impact of this residual contamination on the overall success of the remediation. For the purposes of discussion, dredge cells that did not achieve the <1 ppm PCBs cleanup goal were divided into 4 categories: 1-2 ppm, 2-5 ppm, 5-10 ppm, and >10 ppm. The sediment PCBs discussion concludes with an assessment of the hot spot remediation that addressed sediment with >500 ppm PCBs.

6.1.1.1 Cells With Residual PCB Concentrations 1 – 2 ppm

The 51 dredge cells that had PCB concentrations between 1 and 2 ppm following the 2001 dredging are listed in Table 6-5; the locations of these cells are shown in Figures 6-1 and 6-2. One of the cells with 1-2 ppm (C-64) was capped in 2001 by virtue of its location in the center of a group of cells with >10 ppm PCBs. Six other cells with 1-2 ppm were eventually designated as Mark for Further Evaluation (MFE) in accordance with the Flow Sheet Logic of the *Final Design Report*. MFE cells satisfied the cell-specific remediation requirements as long as the average PCB concentration for the Evaluation Area was <5 ppm and the PCB concentration in the cell was <10 ppm. Consequently, these 1-2 ppm MFE cells will not be discussed further in this section.

Cells with 1-2 ppm PCBs that were not designated MFE cells exceed the ROD-specified cleanup goal of 1ppm. On the basis of field observations, analytical data, the historical correlation between PCBs and other contaminants, and an understanding of the risk reduction goals for the project, however, RMC concluded that no further dredging effort was warranted on these cells. A number of discussions concerning this decision were held with EPA; the basis for making the decision is summarized below.

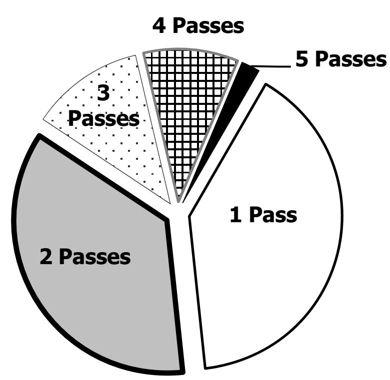
An early factor in the decision to suspend redredging efforts in cells with 1-2 ppm PCBs was related to the verification sampling results from redredging in Area 3-D, one of the first areas to generate second pass verification results. These data showed that, as often as not, there was little progress being made in the attempt to reduce the 1-2 sediment PCB levels to <1 ppm (Table 6-6).

Table 6-5
Dredge Cells with 1-2 ppm PCBs

Cell	PCBs, ppm	Dredge Passes	Eval. Area
A-4	1.14	2	1A
A-10	1.04	1	1A
A-15	1.232	1	1A
A-16	1.6	1	1A
A-17	1.541	2	1A
A-26	1.101	2	1A
A-32	1.546	2	1A
C-3	1.09	1	3C
C-7	1.438	1	3C
C-12	1.24	1	2C
C-17	1.45	1	3C
C-19	1.8	4	3C
C-21	1.489	2	3C
C-23	1.404	3	3C
C-33	1.72	1	2C
C-39	1.86	5	3C
C-40	1.184	3	3C
C-47	1.3	2	2C
C-48	1.37	1	2C
C-49	1.37	3	2C
C-55	1.2	1	3C
C-58	1.26	1	3C
C-64*	1.464	4	2C
C-68	1.926	2	2C
C-74	1.451	3	3C
C-82	1.798	2	2C

Cell	PCBs, ppm	Dredge Passes	Eval. Area
C-85	1.99	2	2C
C-91	1.23	1	2C
D-15	1.79	2	3D
D-17	1.12	1	2D
D-41	1.09	2	3D
D-43	1.5	1	2D
D-76	1.74	3	2D
D-77	1.769	2	2D
D-80	1.074	1	2D
D-84	1.59	3	3D
D-85	1.5	2	3D
D-99**	1.24	2	3D
D-102	1.5	2	3D
D-103**	1.012	2	3D
D-107	1.13	1	2D
D-109**	1.695	3	2D
D-110	1.034	2	2D
D-111	1.31	1	2D
D-114	1.07	1	2D
D-117	1.9	1	2D
D-118**	1.261	4	2D
D-121**	1.52	2	2D
D-122	1.215	4	2D
D-125	1.47	1	2D
D-130**	1.531	4	2D

NOTE: * Capped Cell (1) ** MFE Cell (6)



Dredge Passes for 1-2 ppm PCB Cells

At the same time (early August), first pass verification sampling results from across Area 3-D indicated an approximate 90 percent redredge rate—that is, only about 10 percent of the dredge cells yielded verification sampling results showing PCBs <1 ppm. The project schedule was based on the assumption that approximately 30 percent of the cells would require a second pass, and another 10 percent would require a third or fourth pass.

Table 6-6
Dredging Progress for Selected Area 3-D Cells

	Sediment PCBs, ppm			
Cell	***Pre-Dredge***	***First Pass***	***Second Pass***	***Third Pass***
D-37	1-10	1.19	0.586	--
D-41	1.12*	3.09	1.09	--
D-84	10–25	1.182	2.91	1.59
D-99	1-10	1.708	1.24	--
D-103	1-10	1.503	1.012	--

* D-41 was originally a "no dredge" cell; a verification sample collected after dredging adjacent cells identified PCBs >1 ppm as shown.

Given the results from Area 3-D, it was clear that a much greater redredging effort was going to be needed, with potentially significant impacts on the project schedule. In light of this development, RMC believed that the greatest benefit—measured in terms of contaminant removal from the river—would be obtained by focusing the dredging efforts on cells with higher levels of contamination. Additional dredge passes were completed on many of the cells with 1-2 ppm PCBs; however, these were viewed as a lower priority than cells with higher levels of contamination.

A second consideration was the knowledge that PCB concentrations of 1-2 ppm still attained EPA's targeted residual risk level of $1x10^{-4}$, upon which the 1 ppm cleanup goal for PCBs in sediment was based (as explained in the 1993 ROD and Section 4.3 of the ROD's *Responsiveness Summary*). EPA's 1993 risk assessment (TRC 1993a) and sediment cleanup goal calculations (TRC 1993b) used an oral slope factor for PCBs of 7.7 per mg/kg-day. The slope factor in 2001, according to EPA's IRIS website (www.epa.gov/iris) and published EPA documents, was 2.0 per mg/kg-day. This revised slope factor, which represents the upper-bound (most conservative) slope factors that can be used for PCBs, is specifically identified for use at sites contaminated with a mixture of Aroclors involving food chain exposures (e.g., fish) and sediment ingestion (EPA 1996). Taken together, this information indicated that with the new toxicity data generated by EPA since the 1993 ROD, a PCB concentration of 1-2 ppm—greater than the cleanup goal by a factor of 2 or less—corresponds to a risk level that is at least as protective as that used in the derivation of the original ROD cleanup goals.

6.1.1.2 Cells With Residual PCB Concentrations 2 – 5 ppm

A total of 16 dredge cells were left with PCB concentrations between 2 and 5 ppm (Table 6-7) following the 2001 dredging; the locations of these cells are shown in Figure 6-2. Two of these cells (C-37 and D-119) were designated MFE while a third (C-62) was capped (due to proximity to cells with >10 ppm PCBs). All 16 of the 2-5 ppm cells were located in Areas C and D, with the majority in Area C.

Table 6-7
Dredge Cells with 2-5 ppm PCBs

Cell	PCBs, ppm	Dredges Passes	Eval. Area	
C-13	2.05	3	2C	
C-24	3.09	8	3C	
C-28	2.84	4	2C	
C-31	2.91	1	2C	
C-37	3.94	4	3C	*MFE*
C-60	3.44	9	3C	
C-62	4.19	7	2C	*Capped*
C-71	2.90	5	2C	
C-73	3.93	1	3C	
C-75	2.60	8	3C	
C-79	2.32	2	2C	
C-89	3.65	1	2C	
C-90	2.90	1	2C	
D-112	2.48	3	2D	
D-119	4.37	3	2D	*MFE*
D-123	2.86	4	2D	

Cells with 2-5 ppm PCBs that were designated as MFE cells satisfied the remediation requirements as described for the 1-2 ppm cells. The following discussion focuses on those 2-5 ppm cells that were neither designated MFE nor capped.

Four (4) of the 2-5 ppm cells had only one dredge pass: C-31, C-89, C-90, and C-73. All four of these were resampled at the end of the dredging program as part of the "EPA-Directed Resampling Effort" discussed in Section 6.1.4. As shown in Table 6-8, two of these cells had non-detect verification sample results after the first (and only) dredge pass while the other 2 yielded samples just over 1 ppm PCBs. No additional dredging effort was expended after the initial dredge pass on these 1-2 ppm cells for the reasons detailed above. The higher concentrations identified by the resampling effort became the "final" verification results for these cells; however, dredging activities had ended by the time these data were available.

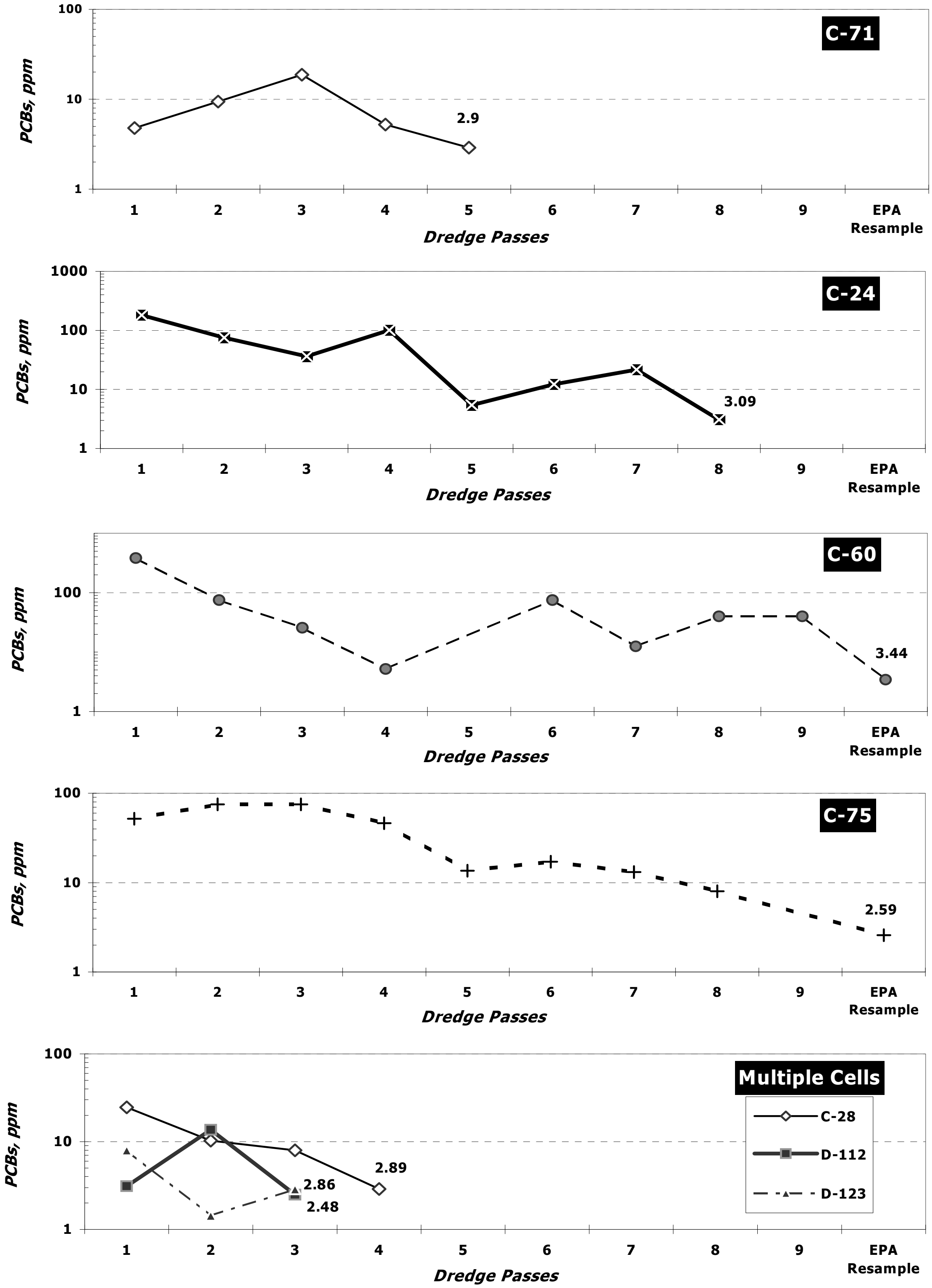
Table 6-8
Analytical History for 2-5 ppm Cells with Only One Dredge Pass

Cell	Dredge Passes	Verification Sampling Result	EPA-Directed Resampling Result
C-31	1	1.13	2.91
C-73	1	1 U	3.93
C-89	1	1.31	3.65
C-90	1	1 U	2.89

One additional cell, C-79, also ended up in the 2-5 ppm category due to results from the EPA-directed resampling effort. C-79 had 1.22 ppm PCBs after two dredge passes; the EPA-directed resampling identified 2.32 ppm. Cell C-13 also had 2 dredge passes with a final verification result of 2.05 ppm PCBs, which was essentially the same as 2 ppm given the analytical and matrix variability observed in the sediment sampling data; no further effort was expended on this cell either.

Figure 6-6 shows dredging progress for the remaining 7 cells in the 2-5 ppm category. The majority of these cells had a large number of dredge passes, which resulted in a significant level of contaminant reduction (compared with the initial or early verification sampling results). Most of these cells are in close proximity to the hot spot area that was eventually capped, and nearly all of them were continuing to be dredged right up to the last week or so of dredging operations (see Cell Status Report in Appendix C). RMC made a concerted effort to get these 2-5 ppm cells as clean as possible before dredging had to be terminated.

The persistence of contamination in these 2-5 ppm cells was not because successive dredging passes were uncovering more (deeper) contaminated sediment. As detailed in Section 3, only minimal quantities of material were actually being removed during the redredging activities, and the quantity of dredged sediment decreased with each successive dredge pass. Only when the Cable Arm bucket was replaced with a conventional clamshell bucket or the hydraulic clamshell of the Cat 350 derrick barge did redredge quantities actually increase. In most cases, however, the materials dredged using the alternative excavation methods was till, stiff silty clays, gravel, and boulders, not the soft sediment that sampling had shown to be the material associated with the PCB (and PAH) contamination.



NOTE: Sample results reflect verification sampling after the indicated dredge pass

Figure 6-6
Dredging Progress for 2-5 ppm PCB Cells (Lab Results Only)

Rather than an indication of greater than expected quantities—or depth—of contaminated sediment, the inability to achieve PCB cleanup goals in the 2-5 ppm cells can be attributed to the likelihood that previous dredge passes had removed all soft sediment and the area (cell) was no longer amenable to dredging as defined in the *Final Design Report.* Dredging in these cells was no longer effective, and it can be argued that the limits of the technology had been reached for that particular location.

The issue of whether the technical limits of dredging had been reached or whether previous dredge passes had rendered the cell not amenable to dredging are also relevant to the discussion of cells with 5-10 ppm PCBs, and >10 ppm PCBs, as well as the remediation of PAHs and PCDF. For this reason, further discussion of these issues is presented in Section 6.1.6.

RMC removed PCB contaminated sediment from these 2-5 ppm cells to the maximum extent practicable, whether due to the limitations of the dredging technology selected for remediation of the site or the cell-specific bottom conditions created from dredging. It is important to note that even with these 16 cells having PCB concentrations between 2 and 5 ppm that the averages across each Evaluation Area (exclusive of capped cells) were still well below the 5 ppm criterion for defining whether remediation requirements had been completed for the area.

6.1.1.3 Cells with Residual PCB Concentrations 5 – 10 ppm

Four (4) cells had final verification sample results with 5-10 ppm PCBs (Table 6-9) following the 2001 dredging. One of these cells (C-63) was capped (due to proximity to >10 ppm PCB cells); the other 3 were designated MFE. The 5-10 ppm MFE cells were included in the statistical evaluation of average PCB concentrations in Evaluation Areas 2 and 3 (as were the 2 MFE cells with 2-5 ppm and 6 MFE cells with 1-2 ppm—there were no MFE cells in Evaluation Area 1). As shown in Table 6-3, average PCB concentrations in Areas 2 and 3 were well below 5 ppm and thus the remediation requirements were satisfied for all of the 5-10 ppm cells.

Table 6-9
Dredge Cells with 5-10 ppm PCBs

Cell	PCBs, ppm	Dredges Passes	Eval. Area	
C-9	5.94	4	2C	*MFE*
C-61	7.73	9	3C	*MFE*
C-63	7.14	7	2C	*Capped*
C-84	6.94	5	2C	*MFE*

Figure 6-7 depicts the analytical progress through verification sampling for the four 5-10 ppm PCBs cells. Sediment samples from these cells yielded a wide range of contamination levels, and similar to the patterns seen elsewhere, the iterative dredge and sample process identified both increasing and decreasing concentrations. Continued dredging removed additional contaminated sediment—and contaminant mass—and eventually lowered the PCB concentrations; however, none of these cells reached the 1 ppm cleanup goal. The dredging and verification sampling history for the 5-10 ppm cells provides additional support to the argument that the technical limits of the dredging technology had been reached. Contaminated sediment was removed to the maximum extent practicable from these four cells, which received a combined total of 25 dredge passes. The verification sampling data support that the residual levels of contamination remaining in these cells could not be removed due to technical infeasibility.

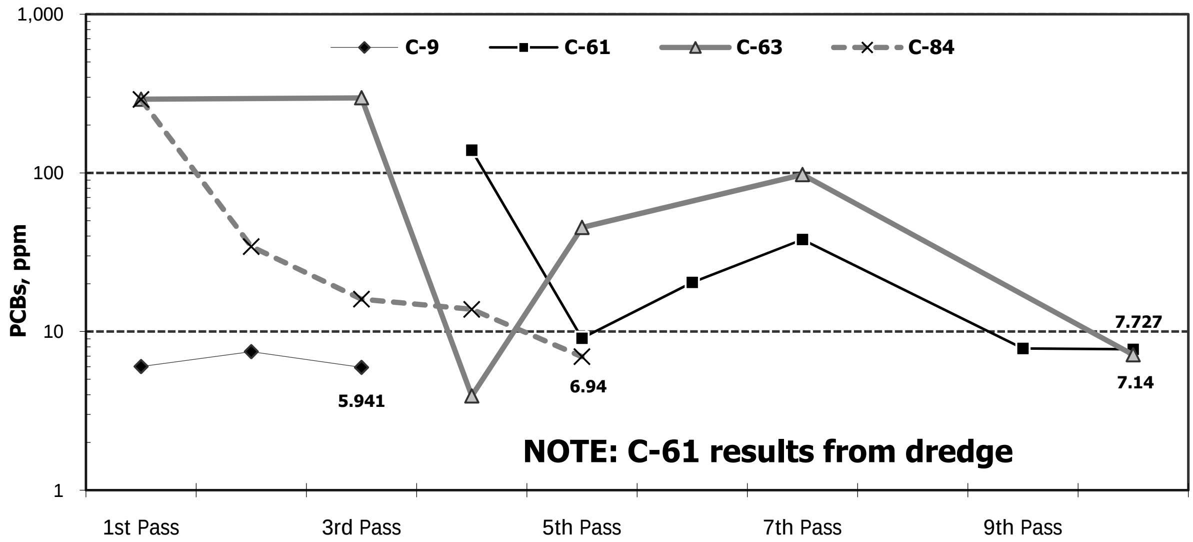


Figure 6-7
Dredging Progress for 5-10 ppm PCB Cells (Lab Results Only)

It is also worth noting that two of the 5-10 ppm cells (C-61 and C-63) were included with the EPA-directed resampling effort. In both cases, the resampling result identified lower results than were obtained from the verification sample collected after the final dredge pass for these cells.

6.1.1.4 Cells with Residual PCB Concentrations >10 ppm

The Final Design stated that individual cells that could not be remediated to below 10 ppm PCBs would be marked for capping. At the end of the dredging effort, a total of 12 cells could not be remediated to concentrations below 10 ppm PCB and were covered with a 2-ft gravel layer as part of the interim capping effort (see Section 3). The locations of these cells were shown in Figure 3-37.

Table 6-10
Dredge Cells with >10 ppm PCBs

Cell	PCBs, ppm	Dredge Passes	Eval. Area
C-27	11.373	3	2C
C-41	19.4	7	3C
C-42	24.012	7	3C
C-43	28.147	7	2C
C-44	44.167	10	2C
C-45	14.097	6	2C
C-46	11.065	1	2C
C-65	14.65	1	2C
C-76	120.457	7	2C
C-77	75.334	4	2C
C-78	20.073	4	2C
C-86	11.1	1	3C

NOTE: All of these cells were capped in 2001

RMC expended considerable effort removing contaminated sediment from these cells, through multiple dredge passes using the Cable Arm bucket, use of a conventional clamshell bucket, and even the hydraulic clamshell of the Cat 350. These efforts met with mixed success, and eventually forced the decision to proceed with capping of the remaining cells with >10 ppm PCBs.

Figure 6-8 summarizes the number of dredge passes and final PCB concentration in the 12 cells left with greater than 10 ppm PCBs and the other 3 cells that were capped due to their being located within the general confines of the capped area (it was easier just to cap these cells given the design for the cap, specifically the required overlap or runout beyond the boundary of the cell to be capped).

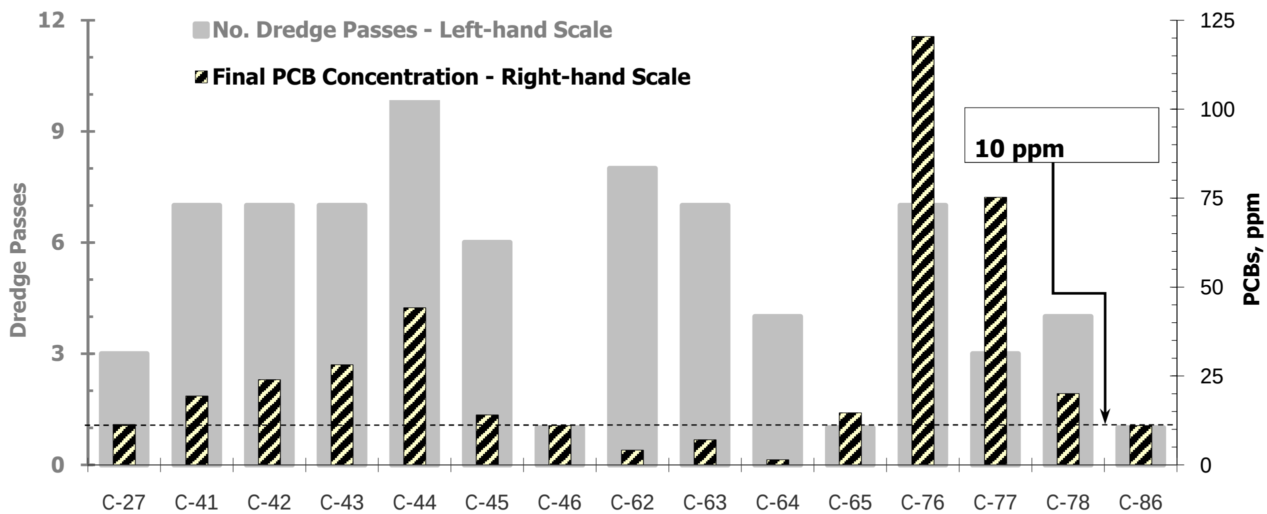
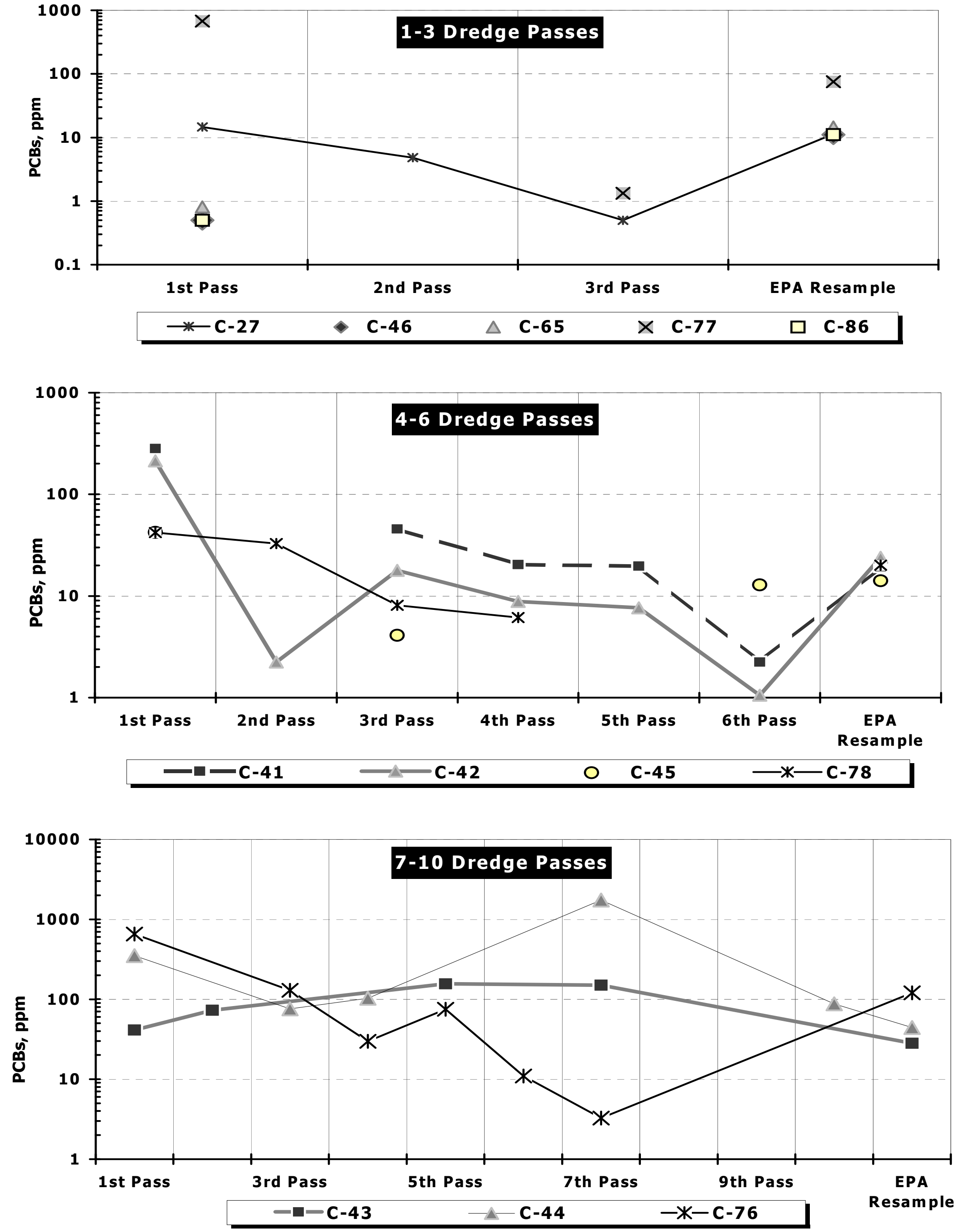


Figure 6-8
PCB Concentrations and Dredge Passes in Capped Cells

As shown on the chart, there was no clear relationship between dredging effort and final PCB concentrations. For example, cells C-41, -42, -43, and –63 all had 7 dredge passes but only C-63 had a final PCB concentration of less than 10 ppm; PCB concentrations in the other 3 cells ranged from 19.4 to 44.2 ppm. Cell C-76 also had 7 dredge passes, and the final verification sample from this cell had 120.5 ppm of PCBs. The absence of any correlation between dredge passes and final PCB concentration for these cells is probably due to a combination of factors, specifically the presence initially of much higher levels of contamination near the former 001 outfall, the characteristics of the river bottom in this area (which included hard bottom, abundant gravel and rocks, based on observations of the material dumped into the scow).

The analytical progress for each cell—a plot of the laboratory sampling results after each dredge pass—provides an additional means to evaluate dredging performance for these cells and provides additional insight into the unpredictable nature of the dredging process in this area (Figure 6-9). The graphs show that in some cases the final PCB concentrations were the same or even higher than those obtained from the initial or early dredge passes. For these cells (e.g., C27, C-42, C-76), numerous additional dredge passes were required just to reduce concentrations back down to the levels seen at the beginning of the dredging process.

In most of the >10 ppm cells, the final PCB number was generated from the EPA-directed resampling effort conducted after dredging activities had been terminated. As detailed above, this resampling effort identified slightly higher concentrations in the handful of 2-5 ppm PCB cells that were included, while lower concentrations were obtained in the resampling of selected 5-10 ppm cells. The fact that nearly all of the >10 ppm PCB cells yielded higher concentrations through the resampling effort, and in some cases significantly higher (up to 2 orders of magnitude), is a trend worth additional analysis.



NOTE: *Sample results reflect verification sampling after the initial dredge pass indicated*

Figure 6-9
Dredging Progress for >10 ppm PCB Cells (Lab Results Only)

Figure 6-10 plots the PCB results from the first and last dredge pass, as well as results from the EPA-directed resampling effort. Three of the cells (C-46, C-65, and C-86) had only one dredge pass as the verification sample result identified <1 ppm PCBs. Six other cells (C-41, C-42, C-76, C-77, C-78 and C-27) were dredged at least 3 times (and in some cases many more) with final PCB results below 10 ppm. Following the collection of samples for the EPA-directed resampling effort, all six of these cells had results >10 ppm PCBs, as did the 3 cells that were non-detect or <1 ppm. The remaining three cells (C-43, C-44 and C-45) all had >10 ppm both before and after the EPA-directed resampling effort.

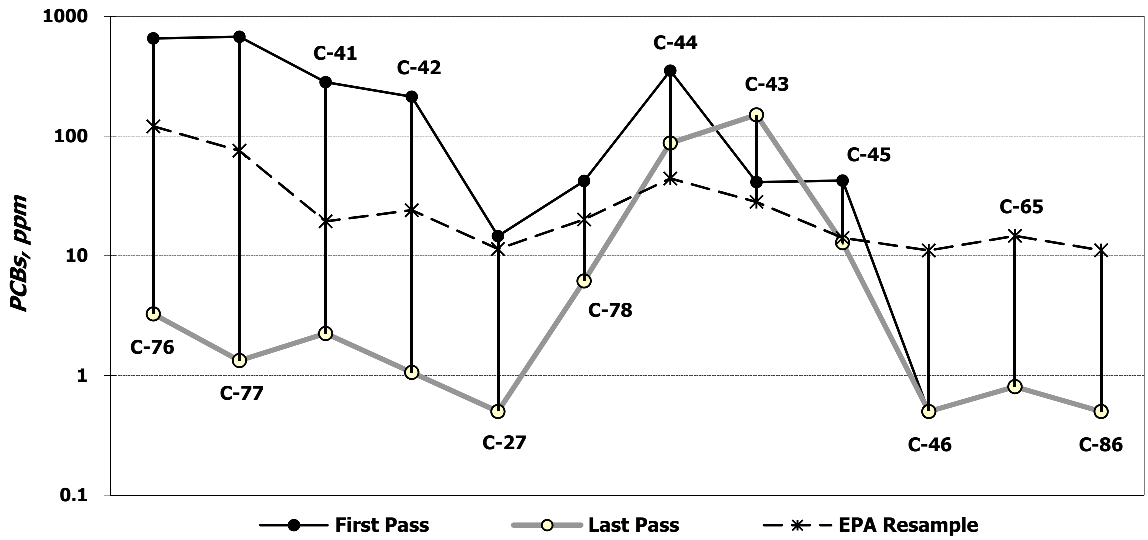


Figure 6-10
Cumulative Progress in >10 ppm PCB Cells

Increasing levels of contamination in 9 of the 12 samples collected for the EPA-directed resampling effort were attributed to the presence of a persistent, thin layer of soft sediment with relatively high (>10 ppm) levels of contamination. This surficial layer was observed in nearly all of the verification split spoon samples collected from this area, and none of the dredging methods employed (Cable Arm, conventional rock bucket, or hydraulic clamshell) were able to fully remove this layer.

The PCB concentrations in the 15 capped cells were excluded from the Evaluation Area average PCB calculations. The final cap for these cells was completed during the 2009 construction season.

6.1.1.5 PCB Hot Spots (>500 ppm)

During the design and planning stage of the project, 8 hot spots were identified in association with historical sampling results showing PCBs greater than 500 ppm (Figure 6-11). All eight of the hot spots were located in Area C, mostly in proximity to the former outfall 001. Additional sampling conducted in April 2001 identified a 9th hot spot in the eastern portion of Area D.

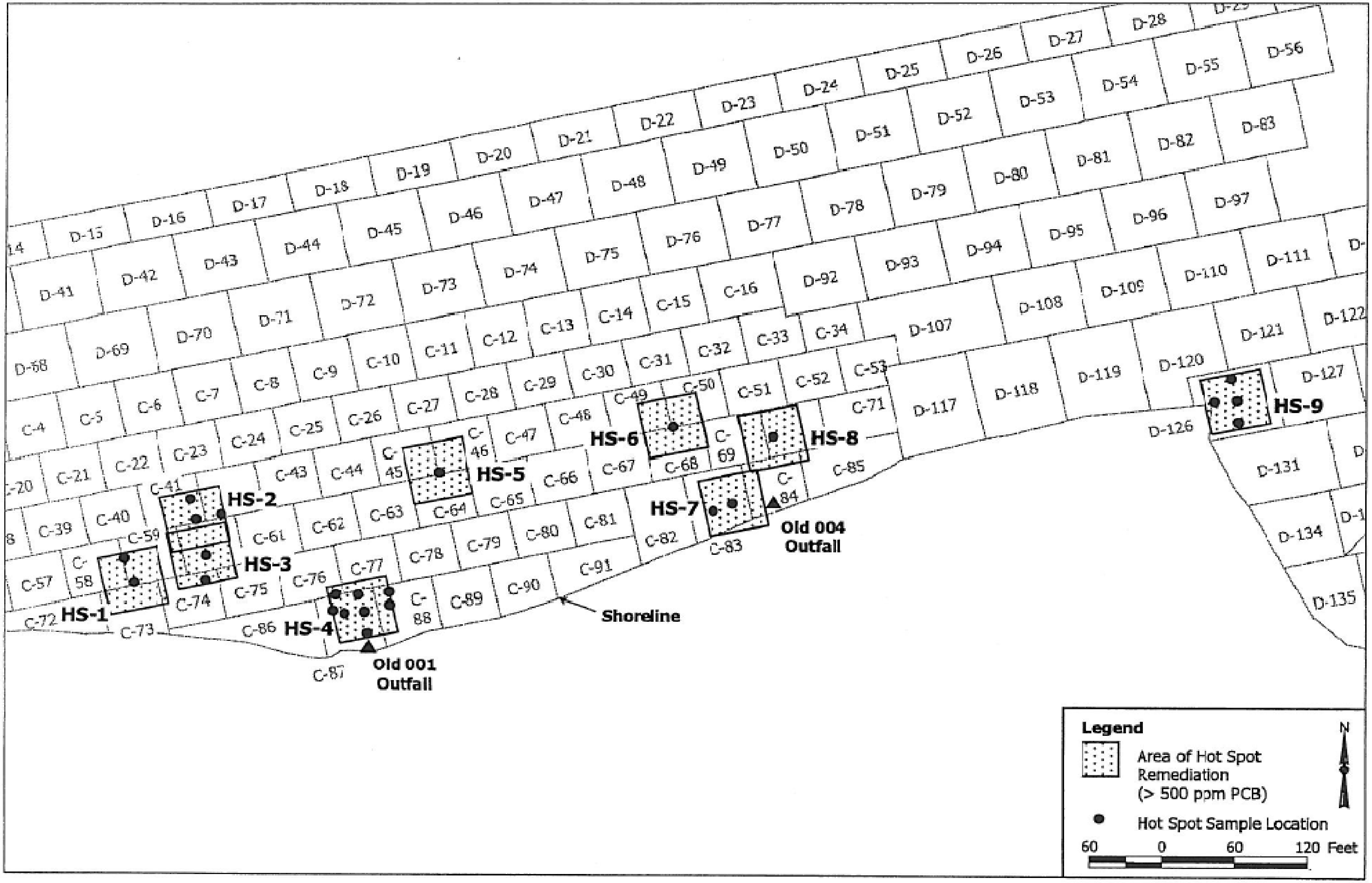


Figure 6-11
PCB Hot Spot Locations

As described in Section 3, the hot spots were dredged using the Cable Arm bucket and then sampled. WINOPS data collected during dredging also identified areas where obstructions were encountered that hindered sediment removal in six of the hot spots. EPA directed RMC to collect biased samples from these areas. The hot spots were divided into quadrants (north, south, east, west), and samples were collected from each quadrant where a significant obstruction was encountered. Where the initial dredging was unable to remove more than the upper few inches of sediment, and the original sampling of the hot spot had identified contamination below 8 inches, a core sample was collected with the retention of 0-8 and 8-16 inch depth intervals. All other samples were from the 0-8 inch interval. Verification and biased sampling results from the hot spots are shown in Table 6-11.

The verification sampling results from the hot spots determined that PCB concentrations in all nine of them had been reduced to concentrations below 500 ppm. Results from the biased sampling, however, identified residual contamination above 500 ppm in HS-4, located immediately offshore of the former 001 outfall. This area was dredged again (i.e., the second pass dredging) following the biased sampling exercise but sampling results again identified >500 ppm PCBs. The hot spot was eventually excavated from the shoreline using the hydraulic clamshell bucket of the Cat 350, after a temporary gravel pad had been constructed for the excavator. Samples collected after excavation with the Cat 350 determined that this third attempt at remediating the >500 ppm material had been effective.

It is important to note the hot spot remediation did not entail the final remediation for any of the hot spot areas. All 9 of the areas were dredged as part of the Area C or Area D sediment removal efforts, and all of the hot spots were eventually sampled again, in some cases numerous times, as part of the verification sampling effort associated with the Area C or Area D dredge cells.

Some of the verification samples collected in Area C later identified sediment with >500 ppm PCBs (Table 6-12). As described in Section 3, these cells were redredged and the sediment was handled and disposed of in accordance with the procedures for >500 ppm material. Follow-up verification samples from these cells indicated that all of the >500 ppm material had been successfully removed.

Table 6-12
Dredge Cells with Verification Samples Indicating >500 ppm PCBs

Cell	Sample Date	Event	PCBs, ppm
C-76	8/14/01	First Pass Verification	654
C-77	8/14/01	First Pass Verification	675
C-76	8/27/01	Second Pass Verification	1,905.4
C-87	9/6/01	Second Pass Verification	875
C-62	9/7/01	Third Pass Verification	1,020
C-44	10/8/01	Seventh Pass Verification	1,750

A final measure of whether the hot spots were successfully remediated, in addition to the sampling results summarized above, can be obtained from examining the final verification results from the dredge cells within and immediately adjacent to the hot spots, including those originally identified and those subsequently identified during the iterative process of verification sampling. PCB data from these locations is shown on the figure of final PCB results for all dredge cells (Figure 6-2). The surrounding cells provide further evidence that all of the hot spots were successfully remediated to below 500 ppm.

Table 6-11
Remediation of PCB Hot Spots: Pre- and Post-Dredging Concentrations (ppm)

	Pre-Dredging PCBs				**1st Pass PCBs**		**2nd Pass**	**3rd Pass**
	0-8”	***8-16”***	***16-24”***	***>24”***	**IAA**	**Lab**	**Lab Only**	**Lab Only**
Hot Spot 1	**500**	--	--	--	10<*x*<50	--		
HS-1N (0-8”)					--	90.24		
Hot Spot --2	140	17	**2,000**	40, 2.6	1<*x*<10	--		
HS-2N (0-8")					--	488.58		
HS-2N (8-16")					--	<1		
HS-2E (0-8")					--	<1		
HS-2E (8-16")					--	<1		
Hot Spot 3	**1,200**	**1200**	<1	--	10<*x*<50	238.4		
HS-3S (0-8")					--	<1		
HS-3S (8-16")					--	<1		
Hot Spot 4	**1,300**	<1	<1	--	>50	83.5		Excavated w/ *Cat 350*; 3 samples collected: HS-4*A*: **109.8** HS-4*B*: **454.4** HS-5*C*: **248.8**
HS-4N (0-8")					--	**1,189.3**	**1,430**	
HS-4E (0-8")					--	60.3	--	
HS-4S (0-8")					--	55.3	--	
HS-4W (0-8")					--	**7,051**	**2,690**	
Hot Spot 5	64	140	**880**		1<*x*<10	--		
Hot Spot 6	<6	**1,200**	1.6	--	1<*x*<10	--		
Hot Spot 7	380	**1,300**	--	--	>50	329		
HS-7W (0-8")					--	40.4		
Hot Spot 8	248	**550**	7.2		1<*x*<10	--		
Hot Spot 9	**565**	<1	<1	--	>50	190.2		
HS-9N (0-8")					--	19.5		
HS-9S (0-8")					--	81.9		
HS-9S (dup.)					--	12.9		
HS-9W (0-8")					--	2.7		

NOTE: IAA = Immunoassay analyses

-- = Sample not collected from this interval or analyzed using the indicated method

HS-4 samples collected after 3rd dredge pass could not be collected from same locations as HS-4N and HS-4W due to excavation method used. The 3 samples that were collected from HS-4 were collected from the areas coinciding with the northern and western quadrants of the hot spot.

6.1.1.6 Biased Sampling Around Obstructions

Sediment samples were collected from 6 cells at locations where obstructions were identified during first or second pass dredging that prevented removal of sediment to design depth. The number and locations of the biased samples was coordinated with EPA prior to collection of the samples, which occurred at the end of the dredging activities. Sample locations are shown in Figure 6-12; sample results are presented below (Table 6-13).

Table 6-13
Biased Sampling Results

	PCB Concentration, ppm	
Cell	**Biased Sample**	**Verification Sample**
C-3	0.62	1.09
C-20	3.68	0.49
C-31	1.31	2.91
C-32	2.46	<1
D-98	0.39	0.70
D-114	0.93	1.07

The majority of the biased sample results showed lower PCB concentrations than were detected in the final verification sample from the cell, indicating that in general there was not appreciable contamination associated with the obstructions. These results provided useful information regarding dredging performance, and in doing so resolved the concern that obstructions were preventing removal of contaminated sediment and that additional "contingency" dredging was needed.

In the course of first and second pass dredging operations at the site, obstructions were encountered that prevented sediment removal in at least portions of a large number of dredge cells. The *Final Design* for the project stated that biased sampling would be conducted at the obstruction to determine whether additional (contingency) dredging was needed. The on-site EPA representatives identified the issue of obstructions, biased sampling, and contingency dredging as a major concern during the construction activities.

Extensive redredging activities (2^{nd} pass, 3^{rd} pass, etc.) were completed for most cells. As part of the redredging activities, the operators attempted to dredge over the entire cell, even where obstructions were identified during first pass dredging operations. Redredging emphasized the removal of all soft sediment, including any and all sediment associated with obstructions, regardless of the nature or size of the obstruction. Considerable time and energy was expended in the attempt to remove or work around and over the obstructions (rocks, boulders, hard pan), and coax what little soft sediment may have been present into the buckets.

Redredging over and around obstructions satisfied the substantive requirements for contingency dredging as described in the *Final Design Report* and *Contingency Plan*. These additional dredge passes were driven by the decision to remove as much contaminated sediment as possible from all cells. Verification sampling results made no distinction between those portions of a cell that were amenable to dredging and obstructed portions not amenable to dredging. The entire cell was redredged whenever the verification sample indicated another pass was needed.

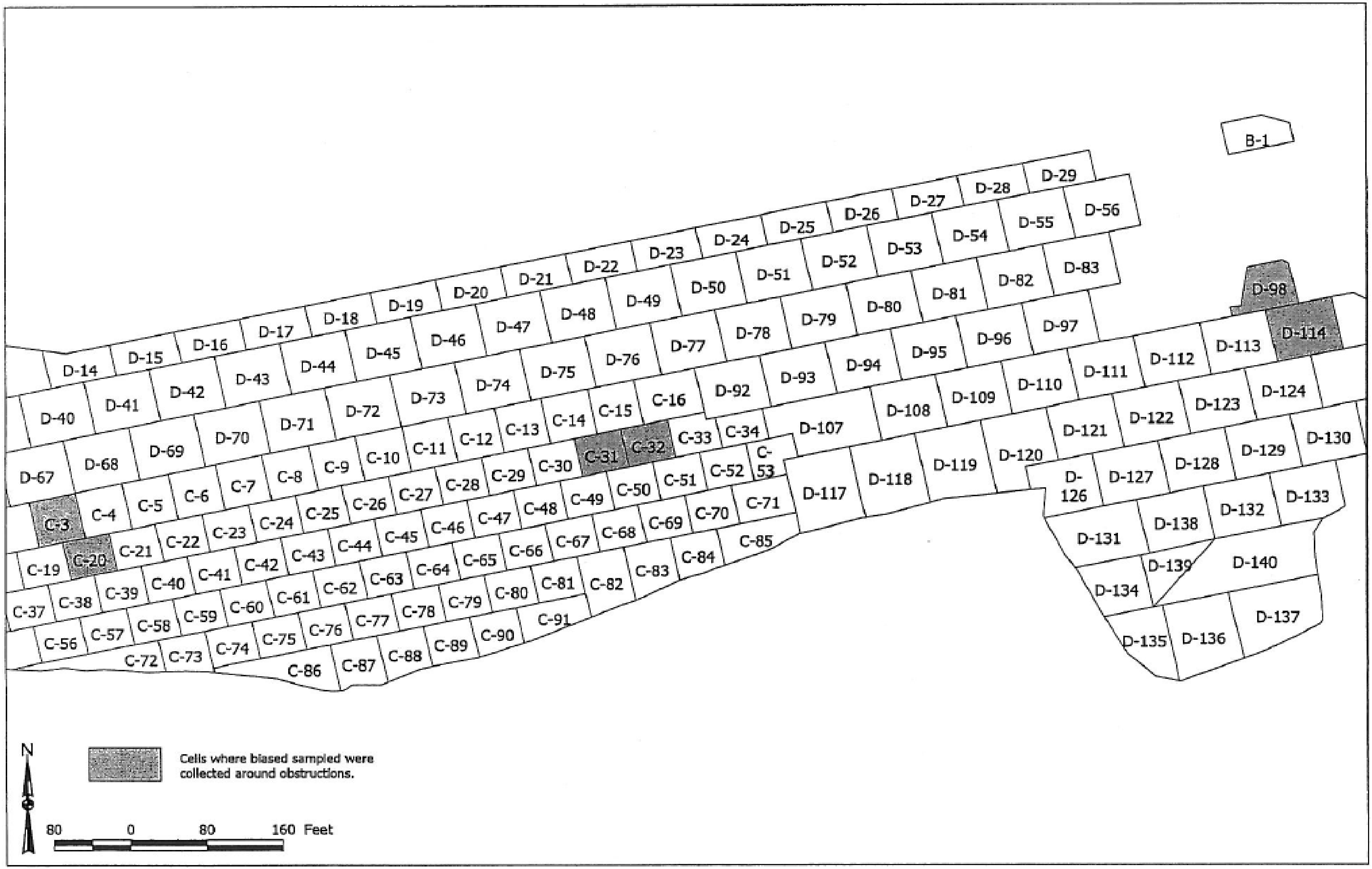


Figure 6-12
Biased Sampling Locations (obstructions)

The collection of biased samples at the conclusion of the dredging program provided further evidence that the redredging had removed contaminated sediment to the maximum extent practicable. Biased sampling results indicate that contamination levels associated with the obstructions are more often than not lower than those obtained from the final verification samples.

6.1.1.7 Shoreline Sampling in Area D

Nine shoreline cells in Area D could not be completely dredged due to shallow water depths that prevented movement of the derrick barges close enough to the shore to dredge the entire cell. The locations of these cells, the approximate boundary of the area that was dredged, and sampling locations are shown on Figure 6-13. The undredged portions of the cells were defined as that area between the edge of dredging and the grass line (~156 ft MSL). The undredged area consisted of approximately 5,700 ft^2 (0.13 acres), the target depth of dredging was 8 inches for three cells and 16 inches for three cells, which equates to a volume of 232 yd^3 (Table 6-14).

Sediment samples were collected from one or two locations within each cell; the number of samples that was collected was based on the size and shape of the area to be characterized. Given the irregular shapes of the areas, it was not practical to follow a systematic sampling grid. Sample locations were selected to provide reasonable coverage of the undredged cell area, providing at least one sampling location for each 1,000 ft^2 of undredged area. Sample results are also shown in Table 6-14.

Table 6-14
Characterization of Undredged Portions of Shoreline Cells in Area D

<table>
<tr><th>Cell</th><th>Target Depth (in.)</th><th>Undredged Area (ft^2)</th><th>Undredged Vol. (yd^3)</th><th>Sampling Location</th><th>Sample Depth (in.)</th><th>PCBs (ppm)</th></tr>
<tr><td rowspan="4">D-84</td><td rowspan="4">16</td><td rowspan="4">1,185</td><td rowspan="4">59</td><td rowspan="2">D-84A</td><td>0-8</td><td rowspan="2">Not sampled (rocks)</td></tr>
<tr><td>8-16</td></tr>
<tr><td rowspan="2">D-84B</td><td>0-8</td><td>6.83</td></tr>
<tr><td>8-16</td><td>0.26</td></tr>
<tr><td rowspan="4">D-99</td><td rowspan="4">16</td><td rowspan="4">1,999</td><td rowspan="4">99</td><td rowspan="2">D-99A</td><td>0-8</td><td>0.1 U</td></tr>
<tr><td>8-16</td><td>0.1 U</td></tr>
<tr><td rowspan="2">D-99B</td><td>0-8</td><td>0.18</td></tr>
<tr><td>8-16</td><td>0.1 U</td></tr>
<tr><td>D-100</td><td>8</td><td>561</td><td>14</td><td>D-100A</td><td>0-8</td><td>0.1 U</td></tr>
<tr><td rowspan="2">D-101</td><td rowspan="2">8</td><td rowspan="2">946</td><td rowspan="2">23</td><td>D-101A</td><td>0-8</td><td>0.1 U</td></tr>
<tr><td>D-101B</td><td>0-8</td><td>0.1 U</td></tr>
<tr><td rowspan="2">D-102</td><td rowspan="2">8</td><td rowspan="2">480</td><td rowspan="2">12</td><td>D-102A</td><td>0-8</td><td>0.1 U</td></tr>
<tr><td>D-102B</td><td>0-8</td><td>0.1 U</td></tr>
<tr><td rowspan="2">D-103</td><td rowspan="2">16</td><td rowspan="2">507</td><td rowspan="2">25</td><td rowspan="2">D-103A</td><td>0-8</td><td>0.67</td></tr>
<tr><td>8-16</td><td>0.1 U</td></tr>
</table>

Note: Cell D-84 was redredged in its entirety after collection of the D-84A and D-84 B samples.

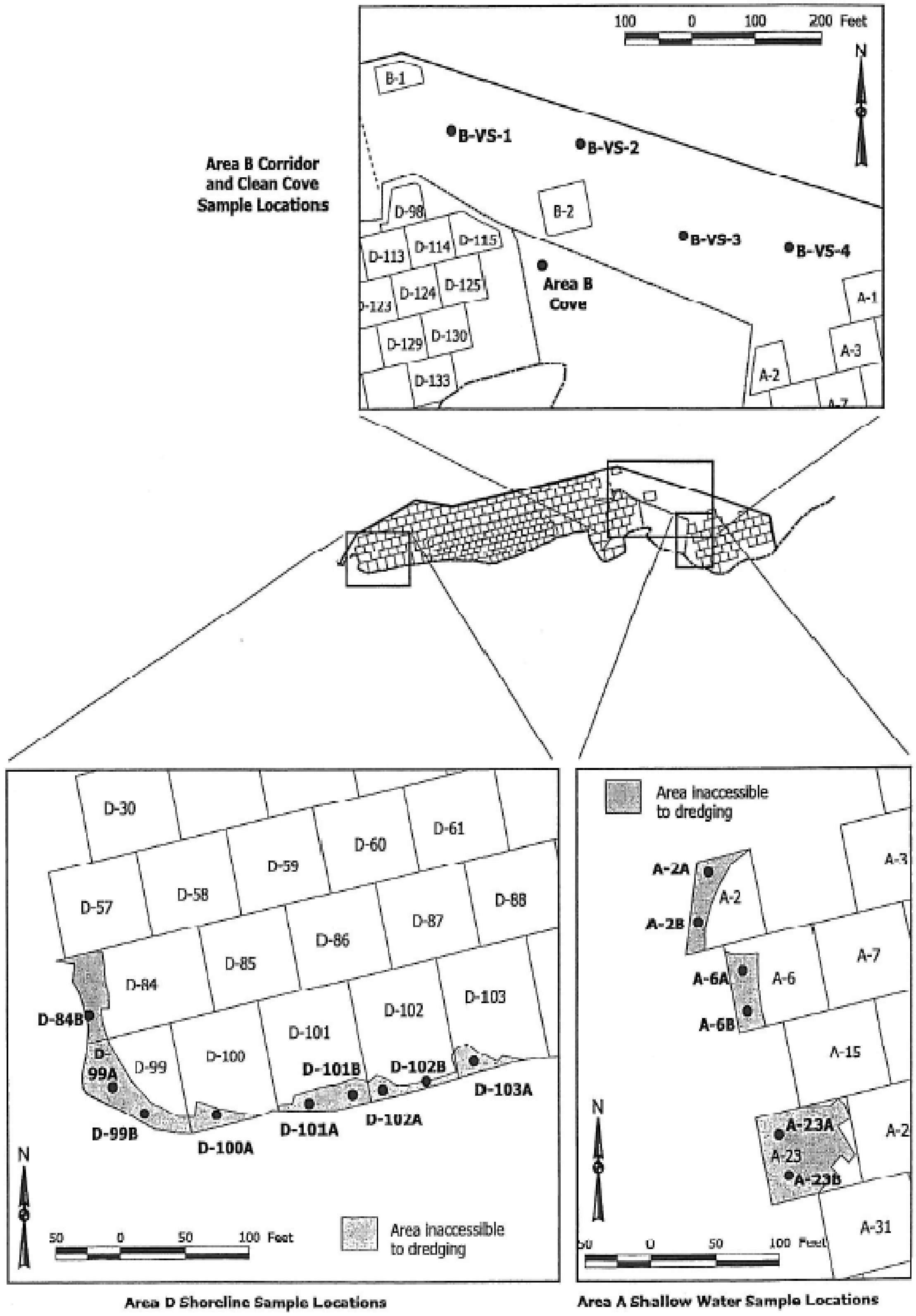


Figure 6-13
Shoreline cells in Area D and Shallow Water portions of Area A

The shoreline sampling effort in Area D determined that the shoreline portions of five of the six cells did not have PCB contamination above the cleanup goal of 1 ppm. The sixth cell, D-84, had contamination above 1 ppm but the cell was dredged twice more, and both passes extended all the way to the grass line. The final verification sample from this cell identified 1.59 ppm PCBs.

6.1.1.8 Biased Sampling in Shallow Water Portions of Area A

Cells A-2, A-6 and A-23 were dredged to the maximum extent practicable using the derrick barges, but it was not possible to access the western portions of the cells due to shallow water and abundant rocks and boulders. The inaccessible portion of each cell is shown in Figure 6-13 of Area A that could not be completely dredged. The approximate boundary of the area that was dredged in each cell is also shown on Figure 6-13. The undredged area, defined as that area between the edge of dredging and the cell boundary, consisted of approximately 5,900 ft^2. The target depth for dredging all three cells was 0-8-inches, which equates to a maximum volume of less than 150 yd^3. Table 6-15 summarizes the areas, depths, and volumes for all three of the cells.

Table 6-15
Characterization of Undredged Portions of Shallow Water Area A Cells

Cell	Target Depth (in.)	Undredged Area (ft^2)	Undredged Vol. (yd^3)	Sampling Location	Sample Depth (in.)	PCBs (ppm)
A-2	8	1190	30	A-2A	0-8	0.30
				A-2B	0-8	0.48
A-6	8	1140	28	A-6A	0-8	0.20
				A-6B	0-8	0.1 U
A-23	8	3540	88	A-23A	0-8	0.1 U
				A-23B	0-8	0.29

Sediment samples were collected from two locations within each cell. Sample locations were selected to provide reasonable coverage of the undredged cell area, providing at least one sampling location for each 1,000 ft^2 of undredged area. Sampling results are also shown in Table 6-15. All results were below the 1 ppm PCB cleanup goal.

6.1.1.9 Sediment Sampling Along Area B Transit Corridor and Inside Area B Silt Curtain

Four sediment samples were collected from the corridor in Area B through which all barges were moved between Area C, Area D and the East Dock. With the exception of two samples that had PCB levels greater than 1 ppm (and subsequently used to delineate dredge cells B-1 and B-2), this area was not contaminated prior to the remediation and was not dredged (except for B-1 and B-2). The objective of the sampling was to confirm that the area had not become contaminated due to dredging operations or barge movement.

The four samples were collected from the locations shown in Figure 6-13. Samples were collected using the split spoon sampler with retention of the 0-8 inch interval for PCB analysis using the immunoassay method. All results indicated less than 1 ppm PCBs.

A sample was also collected from inside the silt curtain surrounding the Area B clean area. The location of this sample is also shown in Figure 6-13. Analysis of this sample also showed PCB levels below 1 ppm, comparable to levels present before the remediation activities. These results showed that the silt curtain was effective in preventing contamination of the area.

6.1.1.10 PCB Summary

An extensive data set was generated to document the successful remediation of PCBs in the St. Lawrence River adjacent to the RMC plant. The final distribution of PCB results is summarized in Figure 6-14. Evaluation of the PCB sampling results identified the following conclusions:

- An approximate 99 percent reduction in PCB concentrations was achieved at the site, as well as the removal of an estimated 20,197 lb of PCB mass.
- All 3 Evaluation Areas had average PCB concentrations well below the 5 ppm criterion defined in the Final Design as the requirement for determining completion of the remediation (for PCBs).
- Although a number of dredge cells were left with PCB concentrations of 1-2 ppm, the residual levels of contamination in these cells are still within the targeted risk reduction targets for sediment as defined in the ROD.
- A smaller number of cells with concentrations of 2-5 ppm and 5-10 ppm were remediated to the maximum extent practicable, given the limits of the dredging technology used at the site and the likelihood that previous dredge passes had rendered the cell not amenable to dredging. The contamination in these cells is below the capping criterion, associated with minimal (if any) excess risk, and does not warrant further attention.
- All cells with >10 ppm PCBs were covered with an interim cap as described in Section 3. Construction of the final cap occurred in 2009.
- All hot spots with PCBs >500 ppm were successfully remediated.
- Biased sampling at obstructions (rocks, boulders) determined that contamination levels associated with the obstructions are more often than not lower than those obtained from the final verification samples. These results also confirmed that redredging satisfied the contingency dredging requirements for obstructions.
- Shoreline sampling in Area D and biased sampling of shallow-water portions of selected Area A cells identified only one area with contamination above the PCB cleanup goal; this area (Cell D-84) was subsequently dredged.
- Sampling along the Area B barge transit corridor showed no contamination resulting from barge movement and that areas isolated by silt curtains were not impacted by dredging operations or nearby barge movement.

6.1.2 Remediation of PAHs

The EMP stated that 10 percent of the cells where the final verification sample indicated <1 ppm PCBs would also be sampled for an expanded suite of analytes that included polynuclear aromatic hydrocarbons (PAHs). Because of EPA concern regarding the extent of PAH contamination in selected areas of the site, additional post dredge samples were collected in 2001 and analyzed for PAHs, both by RMC and EPA. RMC collected samples from 43 dredge cells for PAH analyses; EPA sampling results were generated for an additional 53 cells. All sampling locations are shown in Figures 6-15 (Evaluation Area 1) and 6-16 (Evaluation Areas 2 and 3).

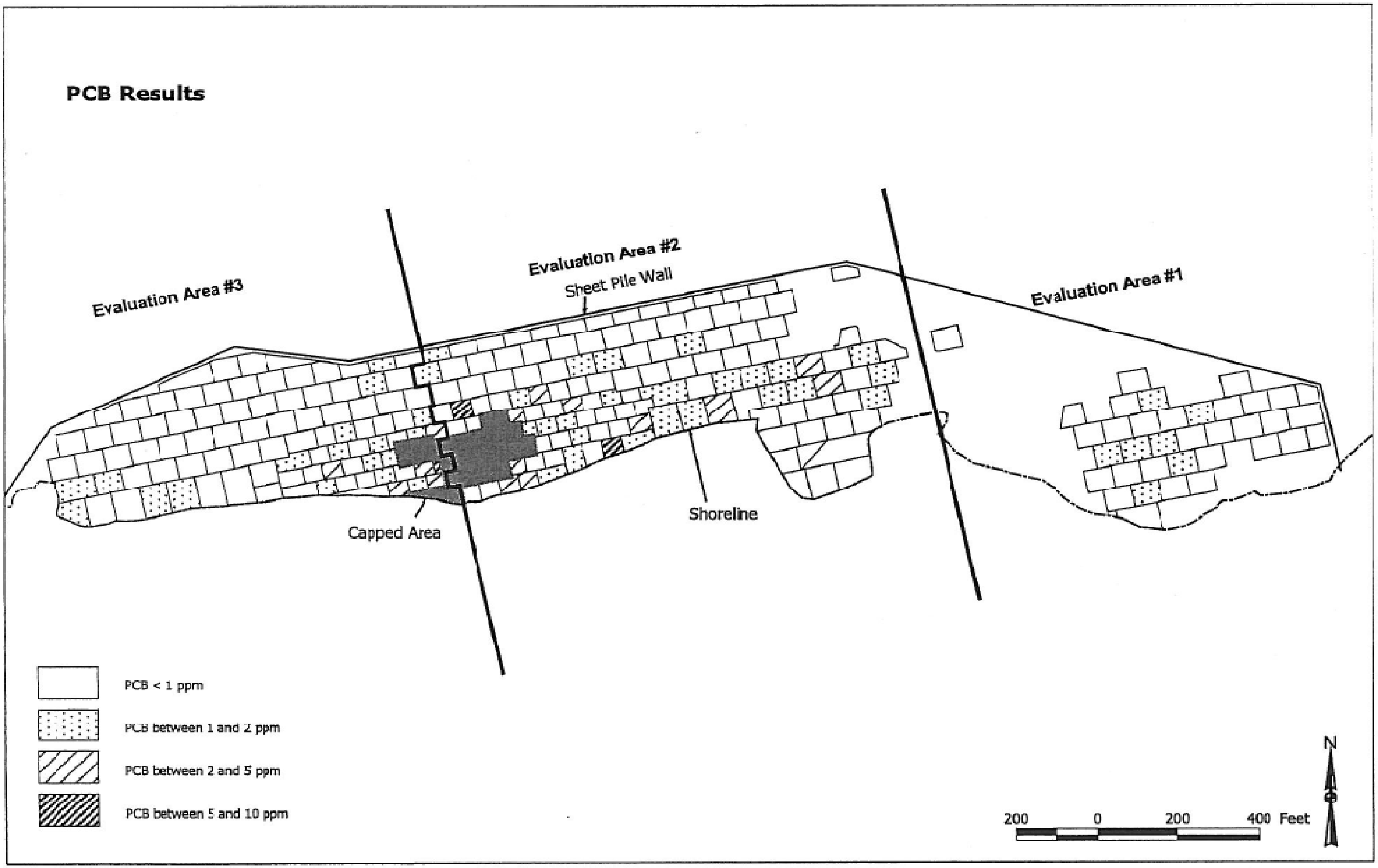


Figure 6-14
Distribution of PCBs in Final Verification Samples

The results from the 96 cells with sediment verification PAH analyses are presented in Table 6-16; only final PAH results (EPA and RMC) from the 2001 sampling are plotted on the two figures referenced above. The list of cells with final verification PAH results includes samples that were taken prior to the final dredge pass. Similar to the situation with PCBs, if the cleanup goal for PAHs was reached but PCBs remained above the cleanup goal, the cell would be redredged and sampled again, but follow-up sampling would be limited to PCBs.

Table 6-17 presents a comparison of final PAH concentrations from the 2001 RMC and EPA sampling and analysis. The comparison of the two data sets is necessary due to the fact that the RMC results were from samples collected on a random basis while EPA samples were biased toward areas specifically thought to be a concern for PAH contamination. The data are presented graphically in Figure 6-17, which shows the frequency distribution for the different concentration ranges of PAHs in sediment.

Although some contrast in the distribution is apparent, the two sample sets generally agree with regard to the occurrence of PAHs at both the low end (non-detect or <1 ppm) and high end (>100 ppm) of the concentration ranges detected. The RMC analyses included a greater proportion of samples with PAH concentrations exceeding the 10 ppm cleanup goal (37 percent, versus 20 percent for the EPA analyses). This discrepancy may reflect the manner in which sample locations were selected but is not believed to be significantly large to preclude combining the data sets for further site-wide analyses (see below).

Table 6-17
Sediment PAH Results in RMC and EPA Verification Samples

	Number of Final Verification Results		
Concentration	**RMC**	**EPA**	**Total**
PAHs <1 ppm	14	18	32
PAHs 1-10 ppm	13	25	38
PAHs 10-50 ppm	11	7	18
PAHs 50-100 ppm	4	2	6
PAHs >100 ppm	1	1	2
Totals	*43*	*53*	*96*

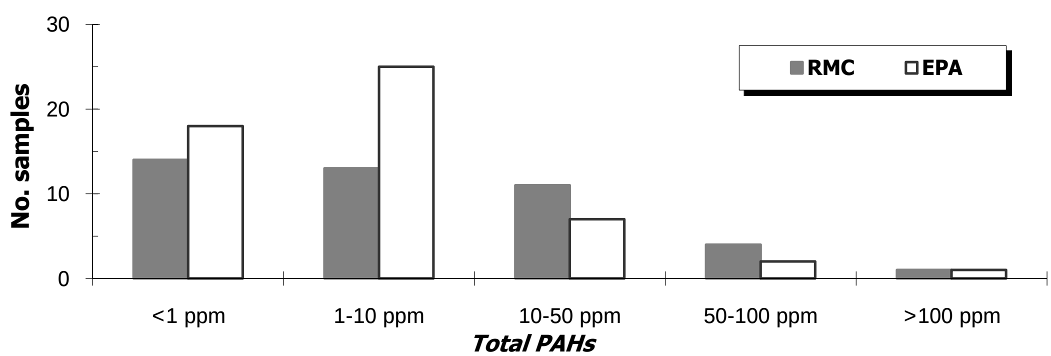


Figure 6-17
Frequency Distribution of PAHs in Sediment Verification Samples

Table 6-16
Final PAH Results for 2001 Sediment Verification Samples

Cell ID	Total PAHs	Date	Source
A-3	**16.40**	10/27/01	RMC
A-5	0.37 J	10/2/01	EPA
A-8	**133.2** E	10/4/01	EPA
A-10	**12.77**	10/4/01	RMC
A-14	**42.42**	10/5/01	EPA
A-19	**16.44**	10/4/01	EPA
A-25	**35.18**	10/15/01	RMC
A-27	0.69	10/27/01	RMC
A-29	4.61	10/6/01	EPA
A-34	1.67 J	10/4/01	RMC
B-2	0.57 J	9/8/01	EPA
C-2	1.97 J	9/19/01	EPA
C-4	2.25	10/3/01	RMC
C-5	0.78 U	11/14/01	RMC
C-6	0.53 U	9/20/01	EPA
C-10	7.58	9/27/01	RMC
C-12	3.79	9/25/01	EPA
C-14	3 J	9/24/01	EPA
C-20	3.69	10/26/01	EPA
C-23	**66.18** E	10/27/01	EPA
C-24	7.53	9/26/01	EPA
C-26	5.02	9/4/01	EPA
C-29	7.85 J	8/14/01	RMC
C-35	8.6	9/25/01	EPA
C-36	**45.33**	11/14/01	RMC
C-39	**244.40**	10/16/01	RMC

Cell ID	Total PAHs	Date	Source
C-41 *	**66.79** E	10/26/01	EPA
C-43 *	**51.31**	10/24/01	RMC
C-44 *	**41.17**	10/8/01	EPA
C-45 *	8.67	10/24/01	RMC
C-57	0.40 J	9/27/01	RMC
C-63 *	**78.94**	10/24/01	RMC
C-65 *	8.75	8/14/01	RMC
C-67	2.01 J	9/11/01	RMC
C-71	6.89	10/26/01	RMC
C-72	0.10 U	10/12/01	RMC
C-74	5.43	10/24/01	RMC
C-75	**39.29**	10/13/01	EPA
C-83	2.62 U	11/14/01	RMC
C-84	8.42	8/30/01	EPA
C-85	3.83	8/30/01	EPA
C-86 *	**21.15**	10/25/01	EPA
C-88	**10.73**	10/13/01	EPA
C-90	5.87	10/26/01	EPA
D-1	0.1 U	9/1/01	EPA
D-2	0.16 U	9/1/01	EPA
D-5	0.30 J	9/1/01	EPA
D-6	1.14 J	9/1/01	EPA
D-7	0.45 U	9/1/01	EPA
D-8	2.07 J	9/1/01	EPA
D-13	0.28 U	9/4/01	RMC
D-14	3.23 J	9/4/01	EPA

Cell ID	Total PAHs	Date	Source
D-16	9.77	9/5/01	EPA
D-19	0.60 J	9/17/01	EPA
D-23	0.84 J	9/17/01	EPA
D-24	6.25 J	9/27/01	RMC
D-26	0.10 U	9/28/01	RMC
D-29	2.74 J	9/6/01	EPA
D-33	2.49 J	9/7/01	EPA
D-35	0.51 J	9/7/01	EPA
D-36	**11.7**	9/7/01	EPA
D-37	1.67 U	9/7/01	RMC
D-40	0.33 U	9/7/01	EPA
D-42	0.55 J	9/4/01	EPA
D-54	0.10 U	10/1/01	RMC
D-65	0.70 J	9/18/01	EPA
D-67	0.56 U	9/19/01	EPA
D-70	2.00 J	8/23/01	EPA
D-73	0.08 U	9/24/01	RMC
D-76	9.61	10/4/01	RMC
D-85	**10.28** J	9/24/01	RMC
D-87	1.39 J	8/30/01	EPA
D-88	2.11 J	8/30/01	EPA
D-90	2.76 J	9/5/01	EPA
D-92	0.23 J	9/24/01	EPA
D-95	0.29 J	10/5/01	RMC
D-99	4.32 --	8/30/01	EPA
D-100	0.34 U	8/30/01	EPA
D-101	0.36 J	8/30/01	EPA

Cell ID	Total PAHs	Date	Source
D-102	**10.22**	9/20/01	RMC
D-103	6.46	9/20/01	EPA
D-104	0.68 J	8/30/01	EPA
D-108	**15.83**	11/23/01	RMC
D-109	0.3 U	11/24/01	RMC
D-110	**85.8**	11/14/01	RMC
D-111	0.37 U	11/14/01	RMC
D-113	6.33	9/6/01	EPA
D-120	0.39 U	10/12/01	RMC
D-121	**28.37**	11/14/01	RMC
D-122	**10.23**	11/14/01	RMC
D-123	**65.69**	11/14/01	RMC
D-129	6.02	9/18/01	EPA
D-130	**10.32**	11/14/01	RMC
D-133	0.09 U	9/27/01	RMC
D-137	0.1 U	10/4/01	RMC

NOTE: ***Capped cell**

U Not detected at concentration shown

J Estimated value

E Exceeded calibration range;

PAH > cleanup goal (10 ppm)

PAH > 10 times cleanup goal

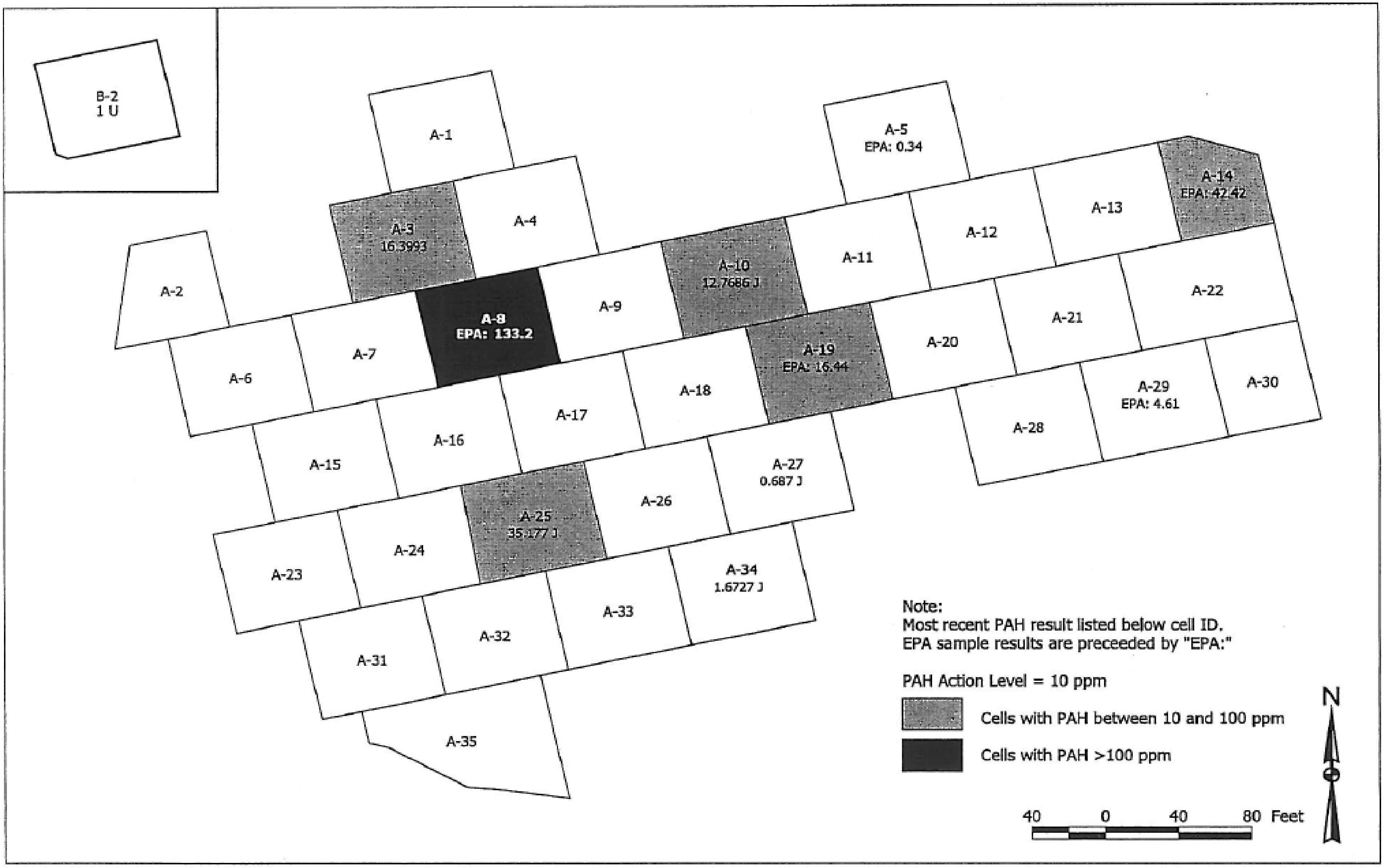


Figure 6-15
PAHs in Evaluation Area 1

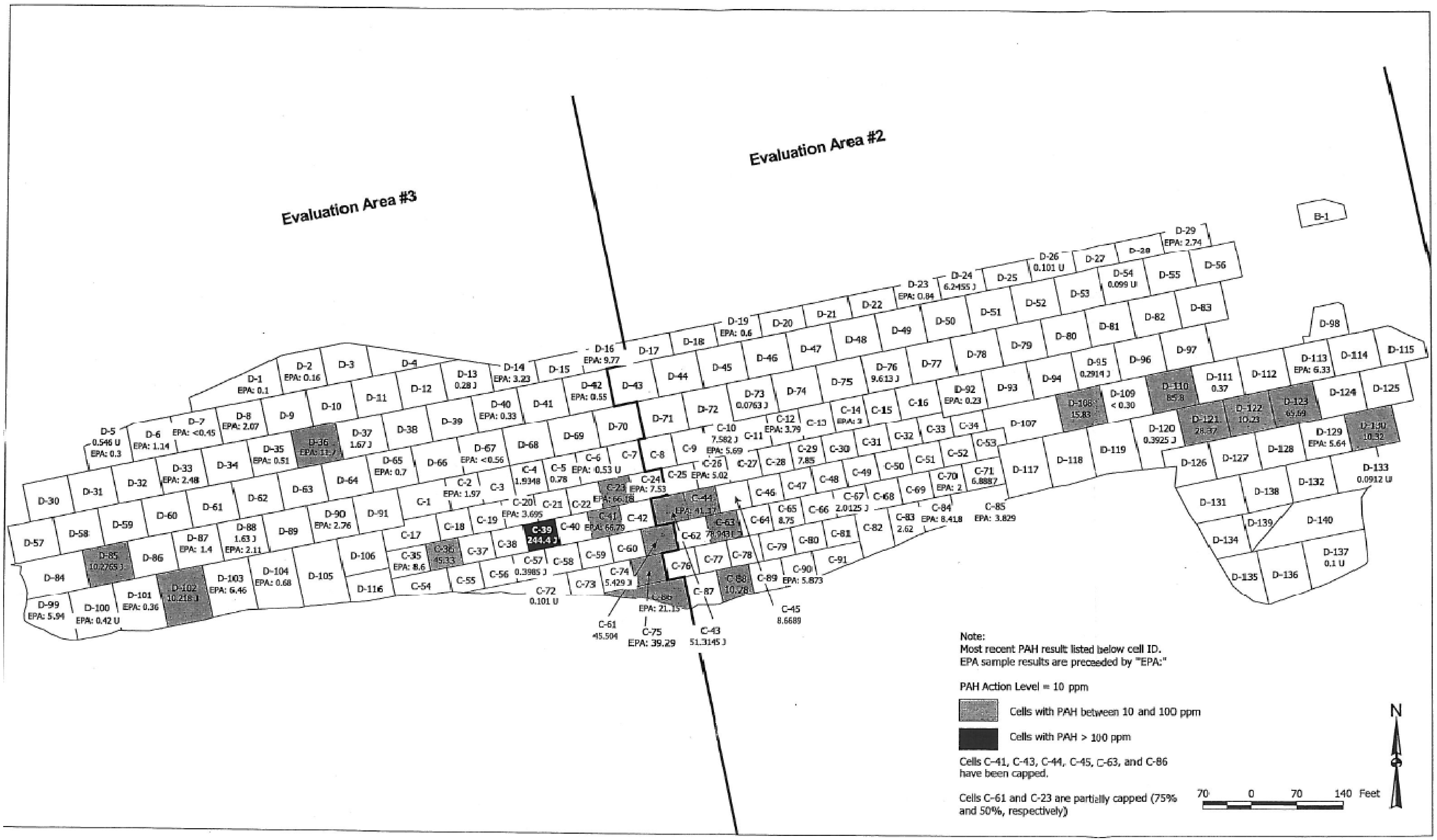


Figure 6-16
PAHs in Evaluation Areas 2 and 3

As shown in the table above, there are 16 RMC verification samples and 10 EPA samples collected in 2001 that had PAH concentrations exceeding the 10 ppm cleanup goal identified for PAHs in the ROD. Five of the cells with >10 ppm PAHs were capped (C-41, C-43, C-44, C-63, and C-86). The 26 cells with PAHs >10 ppm are shown on Figures 6-15 and 6-16 and identified, along with dredging information, in Table 6-18.

Table 6-18
Dredge Cells with PAHs >10 ppm

Cell	Total PAHs (ppm)	Dredge Passes	Cell	Total PAHs (ppm)	Dredge Passes
A-3	16.4	2	**C-63**	78.9	7
A-8	133.2	2	**C-75**	39.3	8
A-10	12.8	1	**C-86**	21.2	1
A-14	42.4	1	**C-88**	10.7	4
A-19	16.4	1	**D-36**	11.7	2
A-25	35.2	2	**D-85**	10.3	2
C-23	66.2	1	**D-102**	10.2	2
C-36	45.3	4	**D-108**	15.8	1
C-39	244.4	5	**D-110**	85.8	2
C-41	66.8	7	**D-121**	28.4	2
C-43	51.3	7	**D-122**	10.2	4
C-44	41.2	10	**D-123**	65.7	4
C-61	45.5	9	**D-130**	10.3	4

NOTE: Shaded cells were capped.

Table 6-18 includes data concerning the number of dredge passes for each of the cells that did not meet PAH cleanup goals; dredge pass data are also summarized in Figure 6-18. Nearly 50 percent of the cells with PAHs >10 ppm had four or more dredge passes, indicating the difficulty in remediating PAH contamination at the site.

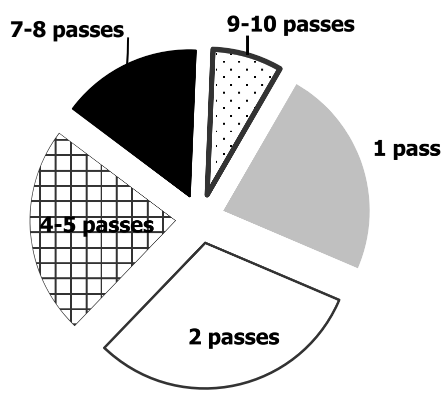


Figure 6-18
Dredge Passes for Cells with PAHs >10 ppm

Similar to the relationship discussed earlier for the cells with PCBs >10 ppm, there was no apparent correlation between the number of dredge passes and the final PAH concentration in the cell. Given the absence of such a correlation, continued dredging would not likely have resulted in a lowering of the PAH levels in these cells

Statistical Evaluation of PAH data

All 96 cells with 2001 post-dredge PAH values also have PCB results. A comparison of these data was conducted to determine the correlation between the two types of data. Figure 6-19 shows scatter plots of PCB vs. PAH data for each Evaluation Area and for the site-wide 2001 data set. A more detailed examination of the correlation between PCBs and PAHs in the post-dredging sediment samples was conducted to determine whether a statistically significant correlation exists regarding the occurrence of these contaminants. The results of this evaluation, which looked at each Evaluation Area individually as well as the complete (site-wide) 2001 data set, are presented in Table 6-19.

Table 6-19
Covariance and Correlation Coefficients: PCBs vs. PAHs in Sediment

Eval. Area	No. Samples	Covariance	Computed *r*	Critical *r*
1	11	3.14	0.3596	0.576
2	41	67.15	0.3896	0.304
3	44	25.41	0.3332	0.291
Site-Wide	96	37.65	0.2048	0.200

Critical *r* values obtained from Table A-11, *Basis Statistical Methods for Engineers and Scientists*, by J.B. Kennedy and A.M. Neville, Harper Row Publishers, New York. 1976.

The covariance is zero when the variables are independent (i.e., not correlated) and thus the closer the covariance is to zero, the weaker the correlation. The correlation coefficient *r* is another measure of the relationship between data sets. The computed *r* for the PCB vs. PAH data is compared to the "critical *r*" which is obtained from statistical tables and corresponds to a specified confidence interval (in this case 95%). When the computed *r* is less than the critical *r*, the variables (in this case PAH and PCB concentrations) are not related (no correlation); when the computed value exceeds the critical value, the data are correlated. As shown in the table, the there is a correlation between PCB and PAH data in Evaluation Areas 2 and 3 but not in Area 1. Site-wide, there is at best a weak correlation, most likely due to the influence of the Evaluation Area 1 data.

Additional statistical evaluations were conducted using just the PAH data, which was divided into three data sets representing each of the Evaluation Areas. Figure 6-20 presents summary statistics and a plot of the distribution of 2001 PAH data from each area. The PAH data were also evaluated using the F test, which is a measure of variance ratios between two data sets. Examination of the variance ratios allows for a determination as to whether the data are drawn from the same population. In this case, the test is to determine whether the PAH data from Evaluation Area 1 represents a different "population" of contaminated sediment as compared to that detected elsewhere on the site, as might be the case for a different contaminant source.

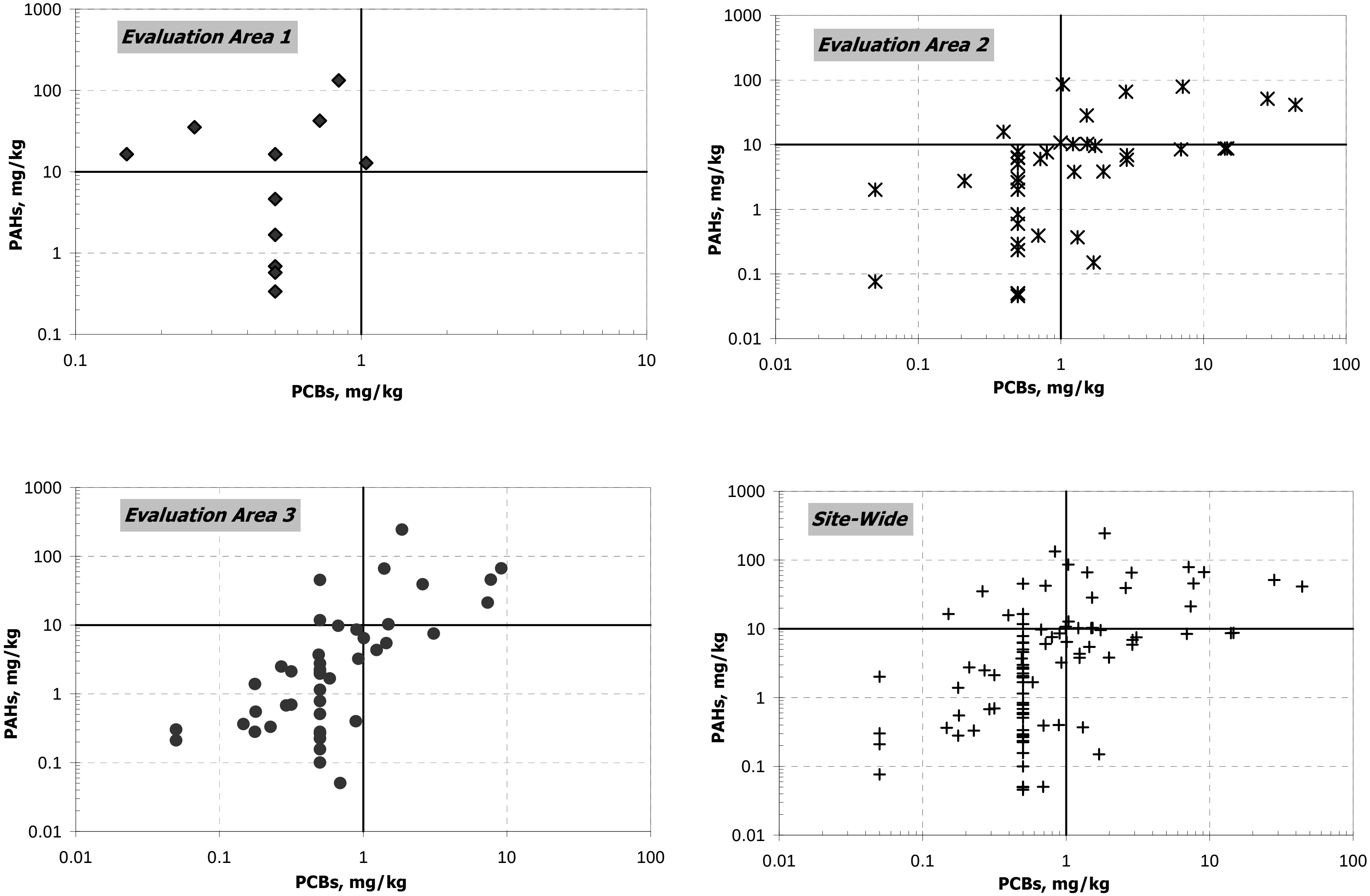
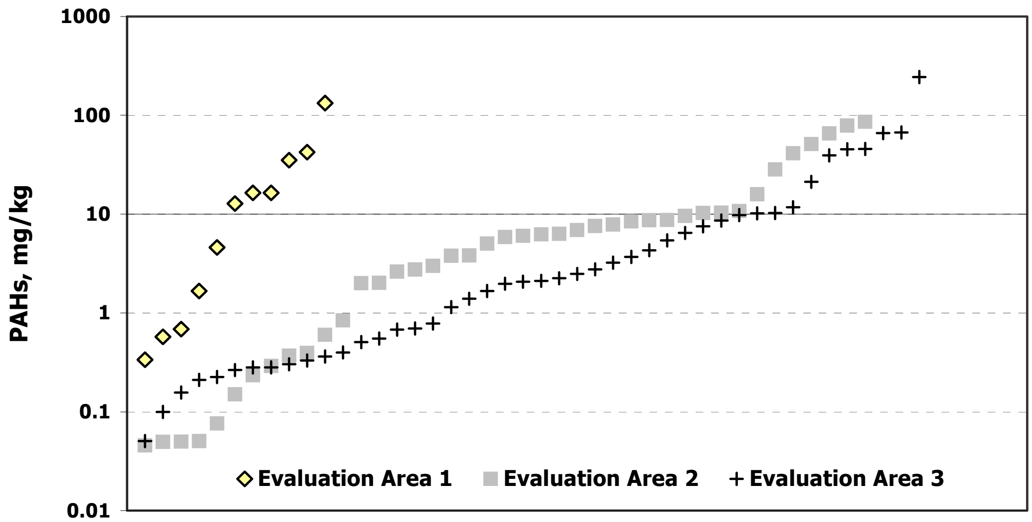


Figure 6-19
Relationship Between PCBs and PAHs in All 3 Evaluation Areas



Evaluation Area 1		Evaluation Area 2		Evaluation Area 3	
Mean	24.026	Mean	12.410	Mean	14.407
Standard Error	11.738	Standard Error	3.315	Standard Error	5.919
Median	12.769	Median	5.873	Median	2.090
Standard Deviation	38.932	Standard Deviation	21.227	Standard Deviation	39.262
Sample Variance	1515.665	Sample Variance	450.581	Sample Variance	1541.519
Kurtosis	7.287	Kurtosis	5.352	Kurtosis	28.469
Skewness	2.587	Skewness	2.468	Skewness	5.013
Range	132.863	Range	85.754	Range	244.353
Minimum	0.337	Minimum	0.0456	Minimum	0.0505
Maximum	133.2	Maximum	85.8	Maximum	244.4035
Sum	264.285	Sum	508.795	Sum	633.893
Count	11	Count	41	Count	44
Confidence Level (95.0%)	26.155	Confidence Level (95.0%)	6.700	Confidence Level (95.0%)	11.937

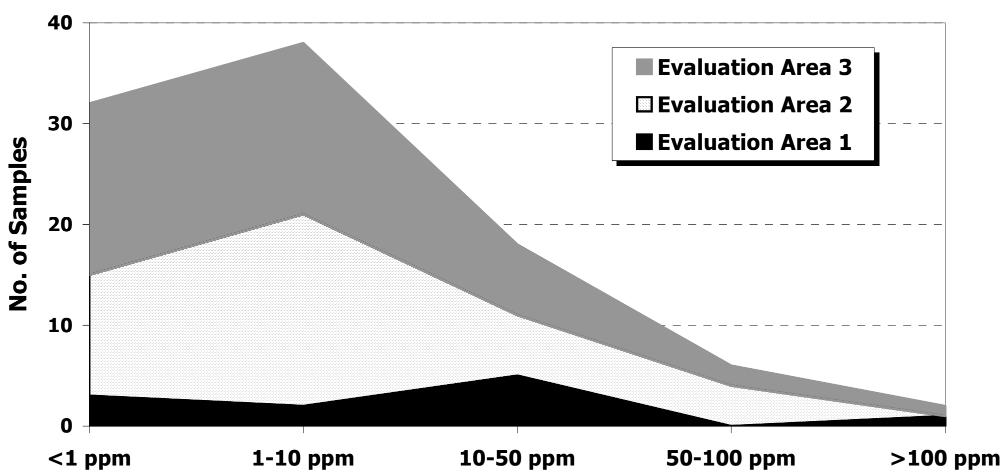


Figure 6-20
Distribution and Summary Statistics for Sediment PAHs

The test involves calculation of an F statistic (the computed F) and comparison to a so-called "critical F" (obtained from statistical tables and corresponding to a specified confidence level—in this case 95%); computed and critical F values are presented in Table 6-20. If the computed F exceeds the critical F, the data represent separate populations. If the computed F is less than the critical F, the data are drawn from the same population.

Table 6-20
F Test for Sediment PAHs by Evaluation Area

	Evaluation Area 1	**Evaluation Area 2**	**Evaluation Area 3**
Mean	24.03	12.41	14.41
Variance	1515.66	450.58	1541.52
Observations	11	41	44
df	10	40	43
Computed F (1 vs. 2)	3.36		
Critical F	*2.08*		
Computed F (2 vs. 3)		0.29	
Critical F		*0.59*	
Computed F (1 vs. 3)	0.98		0.98
Critical F	*0.38*		*0.38*

NOTE: df = degrees of freedom

Critical F values obtained from Table A-10, *Basis Statistical Methods for Engineers and Scientists*, by J.B. Kennedy and A.M. Neville, Harper Row Publishers, New York. 1976.

Comparison of computed vs. critical F values indicates that PAH data in Evaluation Areas 2 and 3 represent the same population, while those from Area 1 represent a different population. This finding supports the previous conclusion that while PCBs and PAHs are correlated in Evaluation Areas 2 and 3, there is no correlation between PCBs and PAHs in Evaluation Area 1. The PAH contamination in Area 1 differs from that detected elsewhere on the site in a statistically significant manner.

It is possible that the contamination in Area 1 was derived from a different source. As discussed in Section 2, hydrodynamic conditions in Area 1 are quite different than those associated with Areas 2 and 3. Area 1 does not have any of the eddy currents or flow reversals that characterize Areas 2 and 3, and is much more likely to be directly affected by flow from Pollys Gut or the Snell Lock. This contrast in hydrodynamic conditions would also affect both the source and pattern of sediment deposition.

Post 2001 PAH Related Activities

The findings from the 2001 post-dredge PAH sampling triggered an extensive dialogue between RMC and EPA regarding the completeness of the PAH data set, the residual risk posed by PAH concentrations which remained after dredging, and the path forward for the project. The actions taken subsequent to the completion of the 2001 construction activities ultimately resulted in the issuance by EPA of an Explanation of Significant Difference (ESD) in 2008. The ESD specified the capping of 53 cells based on residual PAH concentrations, completion of the interim PCB cap, and the excavation of a portion of 4 cells located directly proximate to the shoreline area. Details regarding the history of events following the 2001 construction activities are provided in Volume 2 of this report.

6.1.3 PCDFs

The EMP stated that 10 percent of the cells where the final verification sample indicated <1 ppm PCBs would also be sampled for an expanded suite of analytes that included polychlorinated dibenzofurans (PCDFs). Because of complexities related to the turnaround time in obtaining laboratory analytical results for the sediment samples, a total of 32 final verification samples were collected for PCDF analyses, several more than originally planned (representing 12 percent, rather than 10 percent of the total number of cells); sampling locations (and results) are shown in Figures 6-21 and 6-22. In addition, not all of the cells selected for expanded (PCDF) analyses achieved the <1 ppm PCB cleanup goal.

Table 6-21 presents the PCDF verification sampling results; Figure 6-23 summarizes the distribution of analytical results for the 32 samples that had PCDF analyses. The expanded analyses identified only two cells where the 1 ppb PCDF cleanup goal was not achieved: cell C-43 (4.97 ppb) and C-45

Table 6-21
PCDFs in Final Sediment Verification Samples

	Total PCDFs	1,2,3,4,6,7,8,9-OCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	1,2,3,7,8-PnCDF	2,3,4,6,7,8-HxCDF	2,3,4,7,8-PnCDF	2,3,7,8-TCDF
A-3	611.86	103	94.3	9.98	131	46.8	0.779 J	36.1	27.9	107	55
A-10	137.80	24.8	18	1.61 J	31.5	10.9	0.5 U	9.09	4.8 J	24.1	13
A-27	27.62	2.29 J	1.56 J	0.5 U	5.31 J	2.6 J	0.5 U	3.14 J	0.565 J	8.63	3.52
A-34	38.79	6.97 J	4.22 J	0.578 J	7.71	3.08 J	0.5 U	3.18 J	1.28 J	8.63	3.14
C-4	94.78	2.73 J	3.97 J	0.5 U	20	9.6	0.5 U	11.6	2.18 J	31.7	13
C-10	412.11	10 U	16.4	5 U	95.9	50	5 U	56.6	9.61	143	40.6
C-29	192.97	6.45J	6.15	0.52 J	20.7	7.72	0.5 U	9.38	2.85 J	27.2	112
C-39	639.10	31.4	48.2	5 U	170	58.6	5 U	60	22.3	185	63.6
C-43	**4966.02**	61	128	5.82 J	989	562	0.54 U	791	94.2	1630	705
C-45	**2447.94**	9.72 J	53	1.42 J	485	272	0.5 U	363	36.8	907	320
C-57	205.62	13.8	14.5	1.07 J	52.8	19.1	0.5 U	18.7	7.25	59.3	19.1 J
C-61	980.44	18	33.8	2.04 J	209	95	0.5 U	126	19.6	357	120
C-63	596.05	23.7	26.3	2.35 J	127	50.3	0.5	66.5	13.9	201	85
C-65	222.63	7.11 J	6.96	0.545 J	28.9	10.8	0.5 U	12.3	3.71 J	37.3	115
C-67	42.11	1.95 J	3.01 J	0.5 U	11.3	4.55 J	0.5 U	4.05 J	1.39 J	12	3.86
C-71	304.56	13.6 J	14.3 J	1.02 J	87.3 J	35.3 J	0.5 U	34 J	5.94 J	88.7 J	24.4
C-72	225.74	3.9 J	12.6	0.5 U	64.4	21.4	0.5 U	22.7	7.34	72.1	21.3 J
C-74	305.05	4.9 J	8.81	0.5 U	46.5	17.6	0.541 J	16.8	4.1 J	186.2	19.6
D-5	13.87	1.04 J	1.06 J	0.5 U	3.23 J	1.37 J	0.5 U	1.51 J	0.527 J	3.43 J	1.7
D-13	51.80	1.96 J	2.41 J	0.5 U	10.7	4.86 J	0.5 U	6.3	1.29 J	17.3	6.98
D-24	562.70	33.6	35.9	5 U	126	54.1	5 U	61.7	14.9	177	54.5
D-26	<10	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	2 U
D-37	87.86	8.38 J	8.51	0.843 J	23.2	9.55	0.5 U	7.3	2.46 J	18.6	9.02
D-54	<10	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	2 U
D-73	16.86	1 U	0.967 J	0.5 U	4.66 J	1.86 J	0.5 U	1.84 J	0.557 J	5.46	1.52
D-76	276.00	13.7	15.5	1.15 J	66.4	26.6	0.5 U	29.6	6.65	84.1	32.3

Table 6-25(cont.)

	Total PCDFs	1,2,3,4,6,7,8,9-OCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	1,2,3,7,8-PnCDF	2,3,4,6,7,8-HxCDF	2,3,4,7,8-PnCDF	2,3,7,8-TCDF
D-85	233.70	30.3	27.8	3.33 J	64.2	24.6	0.5 U	17.1	8.67	38.7	19
D-88	69.71	4.34 J	4.3 J	0.854 J	11.1	4.77 J	0.5 U	4.31 J	1.64 J	10.1	28.3 J
D-95	26.32	2.09 J	1.34 J	0.5 U	5.12 J	2.41 J	0.5 U	3.22 J	0.538 J	8.36	3.24
D-102	129.23	42.4	58.6	3.64 J	9.51	5.3 J	0.5 U	1.62 J	1.79 J	4.1 J	2.27
D-133	<10	10 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	2 U
D-137	4.22	1.62 J	0.59 J	0.5 U	0.888 J	0.5 U	0.5 U	0.5 U	0.5 U	0.676 J	0.443

NOTE: *All concentrations in ng/kg (*parts per trillion*)*

*Shaded cells denote concentrations exceeding ROD cleanup goal of 1,000 ng/kg (*1,000 ppt = 1 ppb*)*

OCDF *octochlorodibenzofurans*
HpCDF heptachlorodibenzofurans
HxCDF hexachlorodibenzofurans
PnCDF pentachlorodibenzofurans
TCDF tetrachlorodibenzofurans
PCDF polychlorinated dibenzofurans (total dibenzofurans)
U compound not detected at concentration shown
J concentration estimated

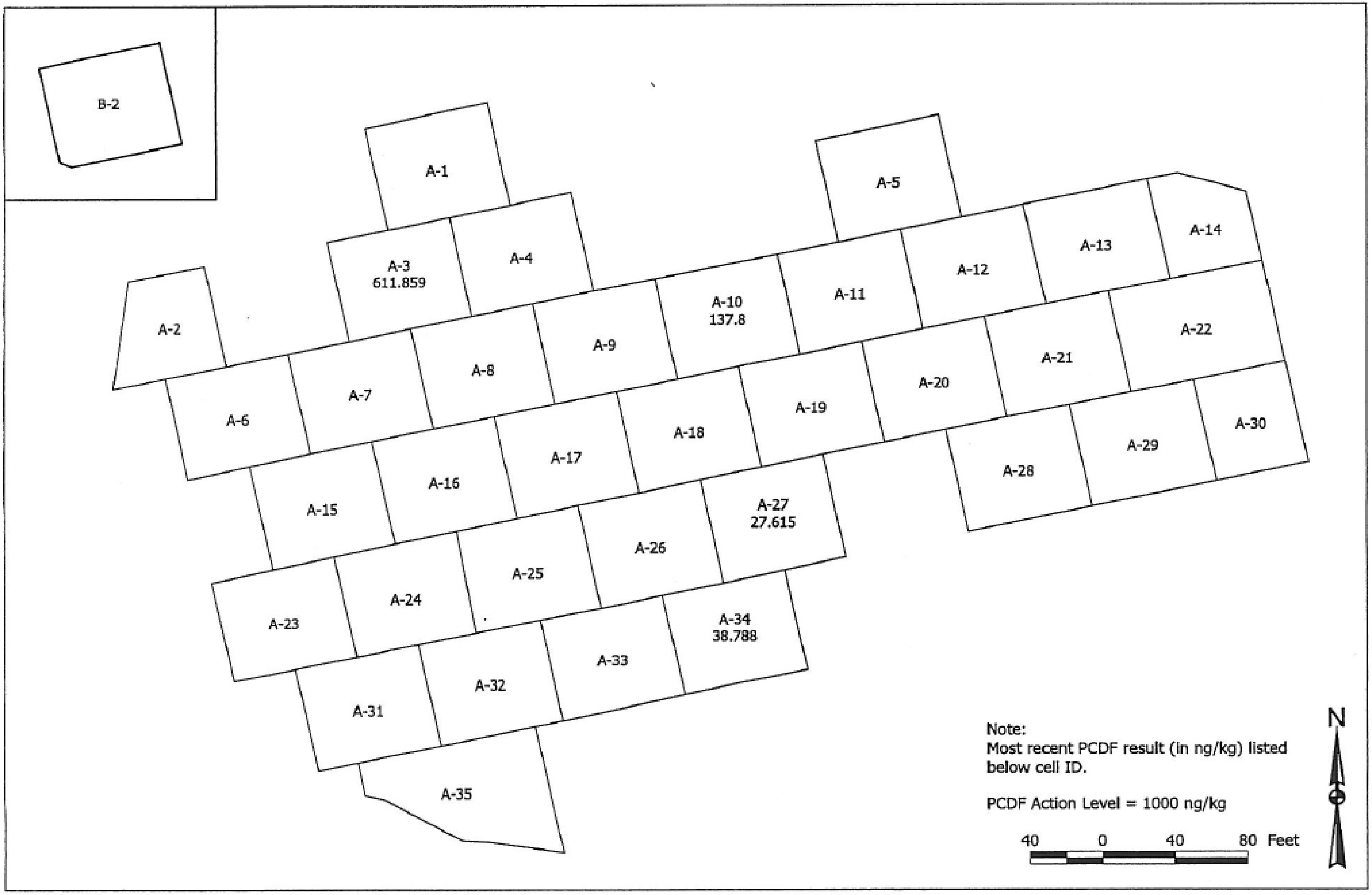


Figure 6-21
PCDFs in Evaluation Area 1

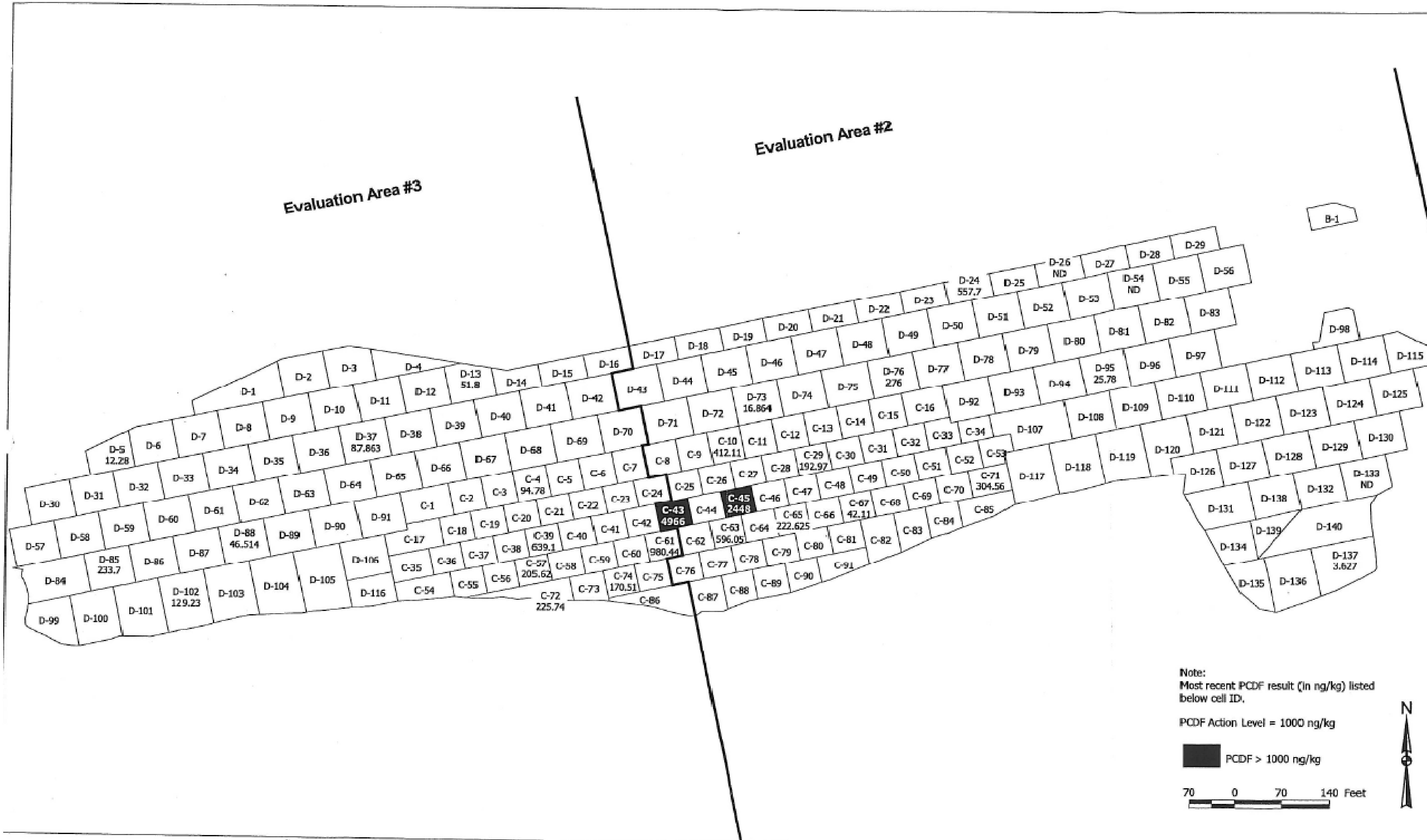


Figure 6-22
PCDFs in Evaluation Areas 2 and 3

(2.45 ppb). Both of these cells were dredged numerous times (seven passes for C-43, six passes for C-45) and a significant quantity of sediment was removed. These efforts were not able to reduce contaminant concentrations to below the cleanup goals for PCDFs (or PAHs and PCBs) in either cell. Both cells were covered with the interim gravel cap at the conclusion of dredging operations.

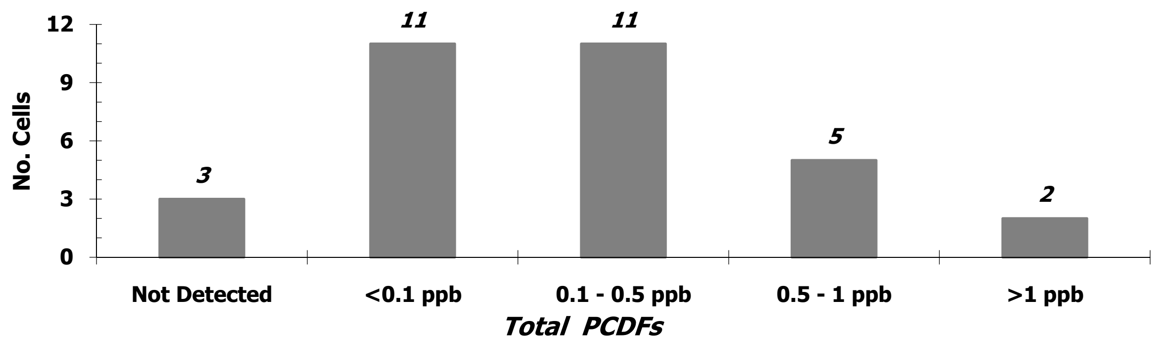


Figure 6-23
Distribution of PCDFs in Sediment Verification Samples

In general, PCDFs were widely detected across the site, in areas associated with relatively high PCB contamination as well as in areas with little to no PCB contamination. Figure 6-24- shows the relationship between PCBs and PCDFs for the 32 cells where both furan and PCB results are available. For the purposes of this analysis, it was assumed that dredging would not selectively remove PCBs or PCDFs but rather was equally effective in removing both types of contaminant. Both PCBs and PCDFs have a strong affinity for sorption to organic molecules and fine grained sediment particles—the type likely to be resuspended during dredging operations. There is no reason to suspect an appreciable contrast in the post-dredging distribution of these compounds due to the resuspension, transport and settling of sediment particles as a result of dredging.

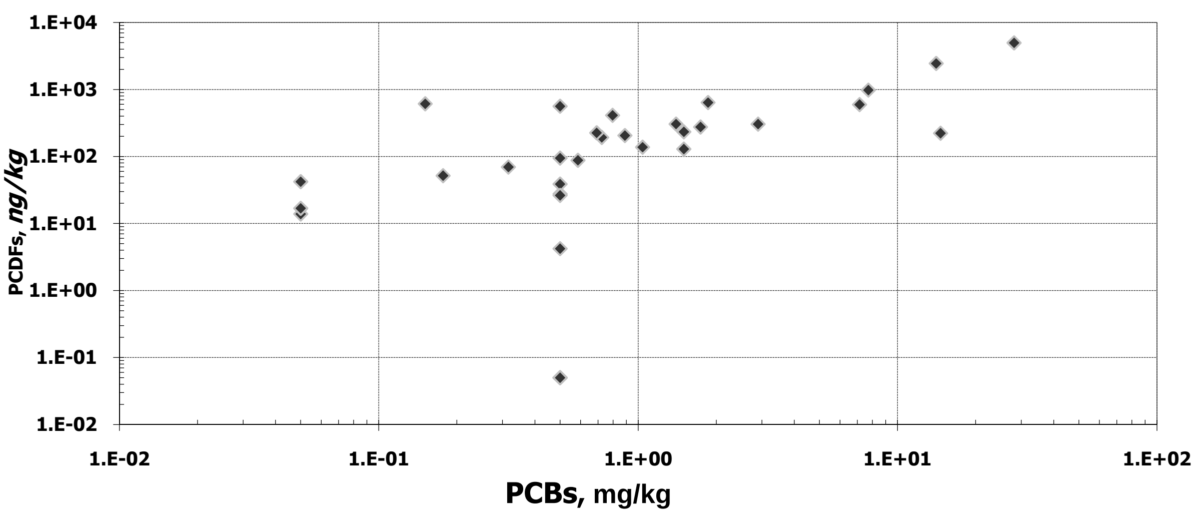
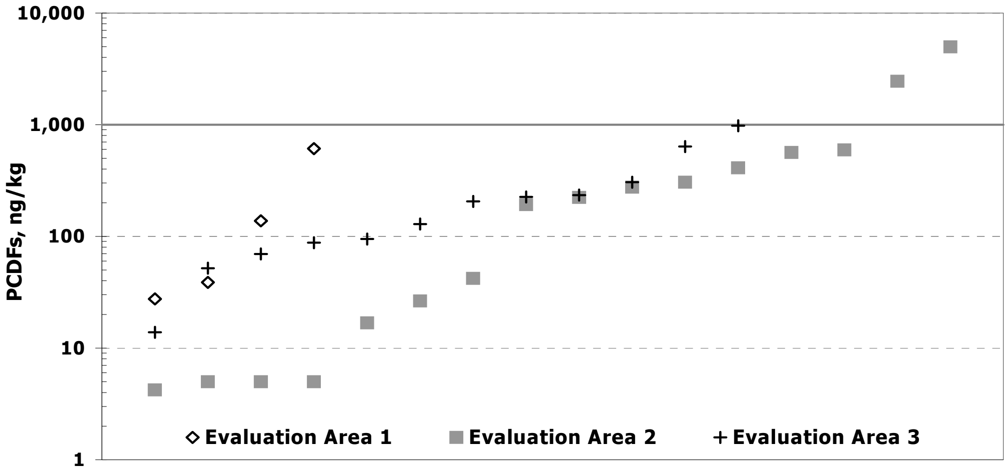


Figure 6-24
PCDFs vs. PCBs in Final Sediment Verification Samples

Figure 6-25 shows plots of the distribution and includes a table of summary statistics for the PCDF sediment data. Table 6-22 presents results of a statistical evaluation conducted on the verification results for cells with both PCB and PCDF analyses. The evaluation was identical to that described for the PAH vs. PCB data set. Similar to the finding for PAHs, there was no correlation between



Evaluation Area 1		Evaluation Area 2		Evaluation Area 3	
Mean	204.02	Mean	630.34	Mean	253.08
Standard Error	138.18	Standard Error	325.30	Standard Error	81.80
Median	88.29	Median	207.79	Median	167.43
Standard Deviation	276.37	Standard Deviation	1301.20	Standard Deviation	283.36
Sample Variance	76379.36	Sample Variance	1693117.99	Sample Variance	80290.41
Kurtosis	3.30	Kurtosis	8.99	Kurtosis	3.54
Skewness	1.82	Skewness	2.96	Skewness	1.94
Range	584.24	Range	4961.80	Range	966.57
Minimum	27.62	Minimum	4.22	Minimum	13.87
Maximum	611.86	Maximum	4966.02	Maximum	980.44
Sum	816.06	Sum	10085.48	Sum	3036.91
Count	4	Count	16	Count	12
Confidence Level (95.0%)	439.76	Confidence Level (95.0%)	693.36	Confidence Level (95.0%)	180.04

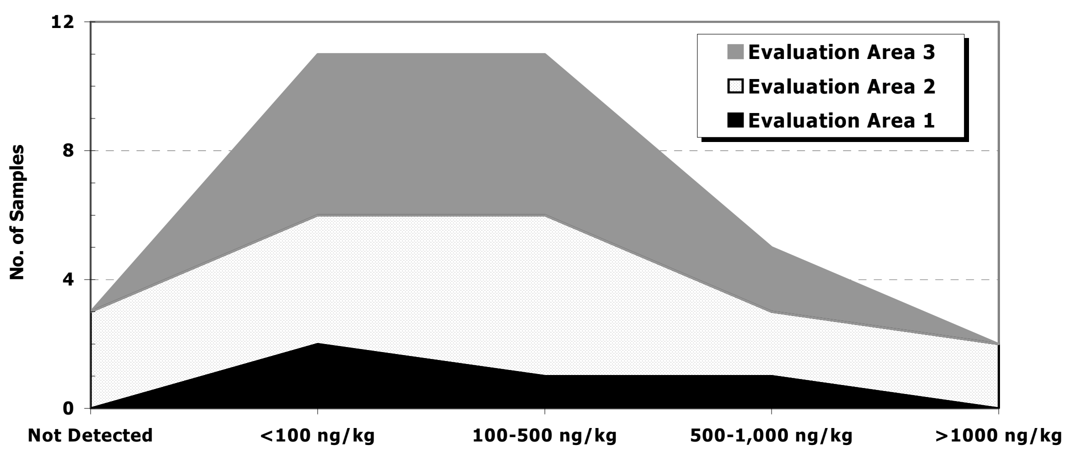


Figure 6-25
Distribution and Summary Statistics for Sediment PCDFs

PCDFs and PCBs in Evaluation Area 1. Conversely, the data in Evaluation Areas 2 and 3, and even on a site-wide basis, display an excellent correlation (the small size of the PCDF data set from Area 1was not large enough to skew the overall correlation for the complete set of data; the size of the data set also precluded an F test as was done for the PAH data).

Table 6-22
Covariance and Correlation Coefficients: PCBs vs. PCDFs in Sediment

Eval. Area	No. Samples	Covariance	Computed *r*	Critical *r*
1	4	-44.52	0.585	0.811
2	16	8608.88	0.894	0.482
3	12	487.38	0.909	0.553
Site-Wide	32	4813.86	0.892	0.347

See Section 6.1.2 for interpretation of computed *r* and reference for critical *r* values.

The site-wide correlation between PCBs and PCDFs confirms previous expectations that remediation of PCBs would effectively remove the PCDFs at the site. Also of interest, is that the only occurrences of PCDFs above the 1 ppb cleanup goal were in cells where PCBs were above 10 ppm, all of which have been capped (interim cap placed in 2001 and final cap placed in 2009; see Volume 2 of this report).

Table 6-23 presents a summary of PCDF results for each of the three Evaluation Areas, including the average detected PCDF concentration as well as the site-wide average concentration. Although there were no specific area-wide or site-wide requirements regarding the average PCDF concentration, the data are useful for comparison with the PCB and PAH data, and indicate that remediation of the site with regard to PCDFs was highly effective.

Table 6-23
Evaluation Area and Site-Wide PCDFs

	Evaluation Area			
	1	**2***	**3**	**Site-Wide**
No. of cells w/ PCDF analyses	10	16	12	32
No. of cells w/ PCDF >1 ppb	0	0	0	0
Avg. PCDF Concentration (ppb)*	***0.204***	***0.152***	***0.239***	***0.197***

* Average concentrations do not include 2 capped cells with PCDFs >1 ppb

6.1.4 Timing for the Collection of Verification Samples

The issue of timing in the collection of the verification samples while active dredging continued in nearby cells was identified by EPA as one potentially impacting the viability of the verification sampling results. The concern focused on the potential recontamination of cells previously shown to be "clean" through verification sampling, due to the effects of dredging nearby after the sampling had occurred. RMC believes this issue was eventually resolved to the satisfaction of EPA; however, it is re-examined below to minimize any further concern regarding the accuracy of verification results.

One of EPA's concerns was that the sediment verification samples were being collected too soon, and should not have been collected until all dredging in the area was complete. The issue of timing in the collection of verification samples is addressed only in the *Environmental Monitoring Plan* (Bechtel 2001), which stated the following:

> Verification sampling will be conducted after sufficient time has passed to allow for settling of suspended solids, and thus it is expected that sampling will be conducted for groups of cells that are at least somewhat removed from the active dredging areas. This approach will minimize the uncertainty that might arise when a cell is sampled relatively quickly after dredging and found to be "clean," but dredging in adjacent cells causes significant resuspension of potentially contaminated sediment. The timing for collection of post-dredging verification sampling will be coordinated with the onsite EPA representative. [p. 6-13]

The EPA-approved EMP stated that sampling will occur after "sufficient time" has elapsed but does not specify a minimum time, as it was understood that such a requirement would be unrealistic in the execution of the work. It was expected that the timing would vary depending on the circumstances of a particular sampling event. For example, for a group of cells to be sampled on a given day, some of the cells may have been dredged 3 days prior to the sampling event while other cells may have been dredged 2 days or even 1 day prior.

As stated in the EMP, the approach to verification sampling was based on the goal of minimizing any uncertainty as to whether clean cells might become re-contaminated through dredging in "adjacent" cells. The actual dredging process did not proceed exactly as expected, due primarily to the much greater amount of redredging effort required. This additional redredging served to complicate the logistics and methods for the dredging activities, which in turn impacted the timing and locations of sediment verification sampling efforts.

The complexity of the dredging program was such that it was not possible to predict whether another dredge pass (i.e., redredging) was needed for a given cell or group of cells. When a group of cells was sampled, some yielded results less than 1 ppm (and were therefore labeled "clean") while others, including possibly adjacent cells, had higher levels of contamination and needed to be redredged. It was not possible to sample only those cells that were clean or redredge only where adjacent cells also needed to be redredged.

These complications were particularly acute in Area C, leading to a complicated pattern of redredging, verification sampling, and more redredging, to be followed by still more verification sampling. Multiple dredge passes were required in certain cells, while others were cleaned up after only one or two passes. Redredging decisions were based on the analytical results from the verification samples, and both the timing and execution of follow-on dredge passes was based on when these results were received as well as the magnitude of any residual contamination. Because of the complexity of the redredge sequencing, it was neither technically feasible nor practical to wait until all redredging was completed before verification samples were collected.

The onsite USEPA representative was informed of the timing and collection of verification samples. Verification sampling plans were discussed every morning at the 7 a.m. meeting, which was attended by the EPA onsite representative. Verification sampling was also discussed at the weekly (Tuesday) schedule meetings, also attended by the onsite EPA representative. Comments from the onsite EPA representative were received in the course of these meetings, and the EPA's concerns regarding verification sampling, particularly in Area C, were communicated at both the meetings and through informal discussions.

RMC agreed to go back and resample 31 cells (for PCBs) selected by EPA to address their recontamination concerns. The results of this sampling effort (termed the "EPA-directed resampling effort) are summarized in Table 6-24. As shown on the table, the resampling determined that a little more than half the samples were more contaminated than the previous sampling result indicated; however, approximately one quarter of the cells that were "resampled" were from cells that had been dredged again but did not have verification samples collected after the re-dredging.. Results from the resampling event served as the final verification samples for these cells and provide no meaningful information regarding the recontamination issue. Consequently, they were excluded from the summary statistics shown in the bottom of the table and depicted graphically in Figure 6-26 below.

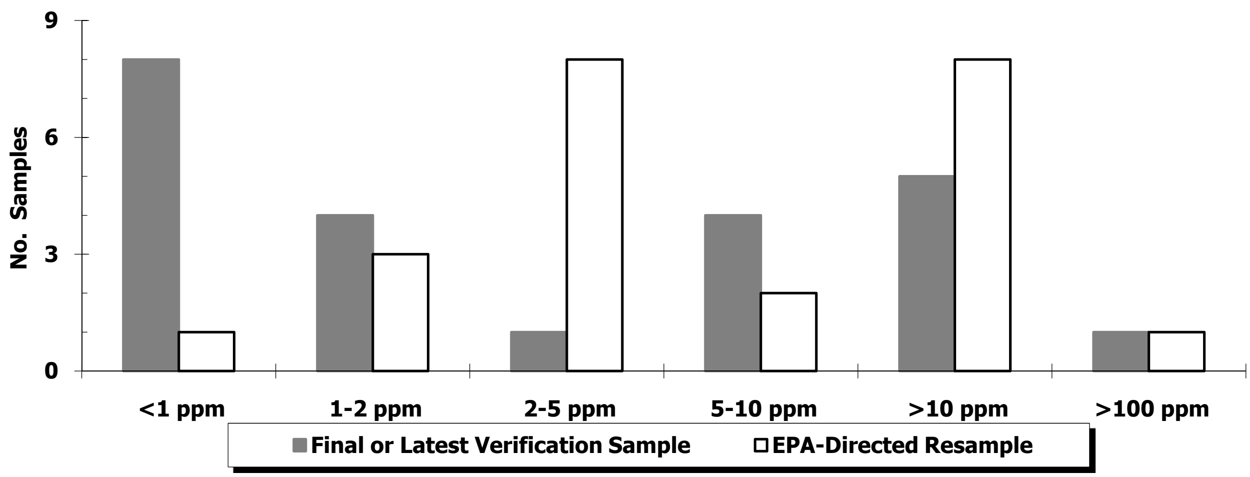


Figure 6-26
Sediment PCB Results from EPA-Directed Resampling in Area C

The resampling effort identified a shift in PCB concentrations in the sediment, and in general a greater number of samples with higher PCB concentrations were obtained, which would suggest recontamination was occurring. At the individual sample level, however, the variation between concentrations was often not very large, and in many instances indistinguishable from the matrix, analytical, and laboratory variability observed in the sediment sampling results collected for the project (additional discussion of the variability in sediment sampling results is presented in the following subsection). Previous sampling efforts had clearly demonstrated that concentrations vary widely within the sediment, between co-located sampling locations and between consecutive sampling events with no change in dredge status. Sampling results also varied between labs, even when the same method was being used and the sample had been painstakingly homogenized.

Another factor to consider in the interpretation of resampling results is that a large number of the resampled cells were dredged using the conventional rock bucket or hydraulic clamshell of the Cat 350 for their final or penultimate dredge passes. As stated in the discussion above for the >10 ppm PCB cells, the use of these alternative methods for sediment removal resulting in increasing levels of contamination in most of the >10 ppm cells. All of these cells eventually capped (interim cap in 2001 and final cap in 2009; see Volume 2 of this report). Use of these alternative dredging methods introduces another variable into the recontamination issue that further complicates its resolution.

Table 6-24
PCB Results from EPA-Directed Resampling Effort in Area C

	Sediment PCBs, ppm			
Cell	**Final or Previous Sample**	**EPA-Directed Resample**	**Delta**	**Comments**
C-20	<1	0.49 (*0.91*)	–	
C-21	0.67	1.49	+	
C-23	1.74	1.40 (*7.00*)	–	Dredged prior to resample
C-25	<1	<1	*same*	Dredged prior to resample
C-26	2.09	<1	–	Dredged prior to resample
C-27	<1	11.37	+	
C-31	1.13	2.91	+	
C-40	1-10	1.18	–	
C-41[a]	2.24	9.15 (*19.4*)	+	Dredged prior to resample
C-42[a]	1.06	24.01	+	Dredged prior to resample
C-43[a,b]	150.17	28.15	–	
C-44[a,b]	87.47	44.17	–	
C-45[a]	12.86	14.10	+	
C-46	<1	11.07	+	
C-59	<1	0.11	–	Dredged prior to resample
C-60[a]	10-50	3.44	–	
C-61[a,b]	7.82	7.27	–	
C-62[a,b]	11.02	4.19	–	
C-63[a,b]	97.55	7.14	–	
C-64[a]	1.37	1.46	+	
C-65	0.81	14.65	+	
C-73	<1	3.93	+	
C-74	1.40	1.45	*same*	Dredged prior to resample
C-75[a]	1-10	2.60	–	
C-76[a]	3.26	120.46	+	
C-77	1.33	75.33	+	Dredged prior to resample
C-78[a]	6.16	20.07	+	
C-79	1.22	2.32	+	
C-86	<1	7.73 (*11.1*)	+	
C-89	1.31	3.65	+	
C-90	<1	2.90 (*2.15*)	+	

Summary exclusive of shaded cells:
9 cells where the resample had the same or lower PCB concentration (39%)
14 cells where the resample had higher PCB concentration (61%)

NOTE: *a* dredged with conventional rock bucket
b dredged with hydraulic clamshell bucket (Cat 350)
Values in parentheses identify EPA split sample result

6.1.5 Variability in Sediment Sampling Results

Sediment verification sampling and analysis identified a significant level of variability in the concentrations of both PCBs and PAHs. This variability complicated the measurement of progress for the sediment removal efforts and decisions regarding the onshore handling and disposal of dredged sediment. The following discussion describes the types of variability that were observed in the sediment PCB results (which have a much larger database for evaluation). The intent is not to resolve the issue one way or another, but rather to facilitate a more detailed understanding of both the occurrence and significance of variability, as well as its potential impact on remediation decisions at the site.

As described above, sediment cleanup verification samples were collected after each dredge pass. In addition to the regular sampling, a large number of split samples were collected and analyzed by EPA, DEC and for internal QA/QC. Additional sediment samples were also collected from many cells even though no further dredging had occurred, either for informational purposes or as part of the EPA-directed resampling effort.

Sediment samples were analyzed for PCBs using Method 8082 (Method 8270 was used for some samples but its use was curtailed as directed by EPA). A total of seven different laboratories conducted sediment PCB analyses in the course of the 2001 dredging work; these labs include:

- Alcoa,
- AXYS,
- Galson,
- Paradigm,
- DEC lab in Watertown,
- DEC's contract lab (Columbia), and
- EPA's contract lab (Mitkem)

The resulting database from these different types of samples, different laboratories, and different analytical methods showed significant variability, between labs, between sampling events, between methods, even between different parts of the same sample jar. The observed variability in a given sample generally can be attributed to one or more of three types of variability:

- Matrix variability: heterogeneous distribution of contamination in the sediment, both on the river bottom and within a sample jar.
- Inter-lab variability: split samples analyzed by different labs using the same method generate divergent results.
- Analytical Variability: split samples analyzed in the same lab generate variable results when different methods are used, and, to a lesser extent, even when using the same method.

Five types of analytical data are available for evaluation of the variability in PCB results; these data represent the following:

1. Split samples analyzed by different laboratories using the same method
2. Successive sampling events from the same location before any additional dredging or other changes in cell status

3. Split samples analyzed by the same analytical method in the same lab
4. Split samples analyzed by different analytical methods in the same lab
5. Split samples analyzed by different analytical methods in different labs

Figure 6-27 shows PCB results for the initial group of split samples sent to different labs for 8082 analyses; most of these samples were collected in July and August 2001. Sediment verification samples were sent to Galson laboratory to reduce sample load on the Alcoa lab while those sent to AXYS were done so as a QC check on results from the Alcoa lab. Paradigm lab analyzed several split samples as part of an immunoassay analysis verification study. Also included are EPA's first two split samples, collected at locations D-67 and D-90.

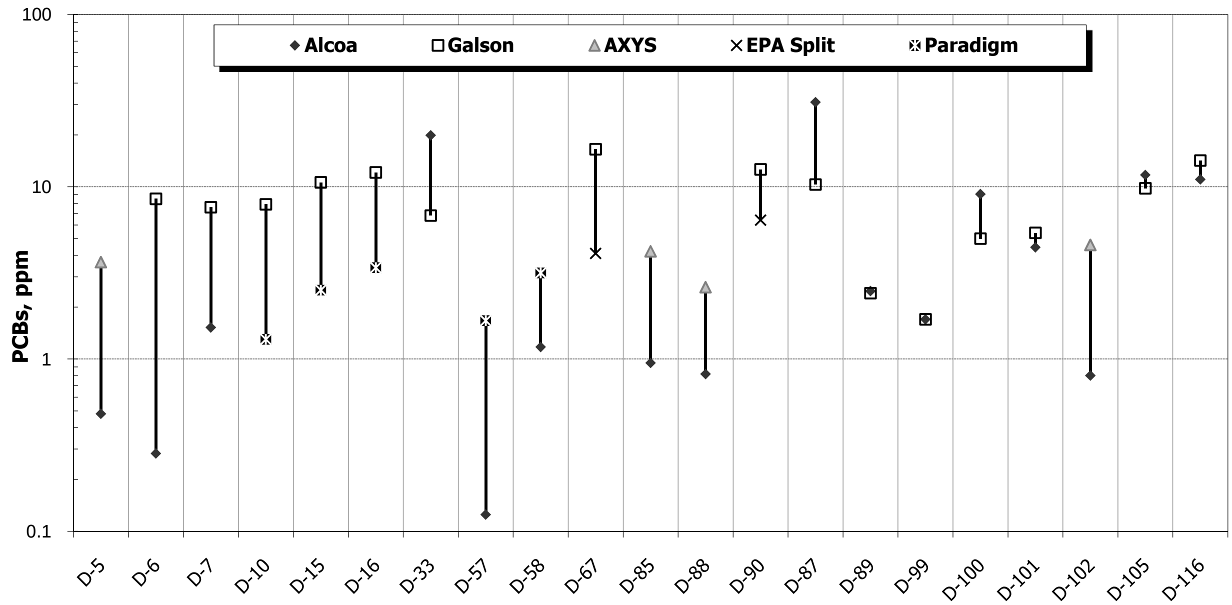


Figure 6-27
PCB Results from Initial Batch of Split Samples (Method 8082 Only)

Potentially significant discrepancies were identified in the 8082 data being generated by the labs. For example, the Galson results were consistently higher than those obtained by the Alcoa lab as well as Paradigm and the EPA lab. The contrasts in PCB results are noteworthy primarily because of their magnitude and the fact that significant discrepancies were observed between all of the labs, not just Alcoa and Galson. These results are excellent examples of the inter-lab variability.

Results from a later batch (August-September) of split samples are shown in Figure 6-28. Due to on-going concerns regarding the accuracy of sediment sampling results, EPA was collecting a greater number of split samples and additional split samples were being taken and analyzed by DEC. Of interest is the generally close agreement obtained between the AXYS and EPA results (both using Method 8082), and the generally poor agreement between the Alcoa lab (a mix of 8082 and 8270 data) and DEC lab (8082 only, although analyses for 8270 were also completed).

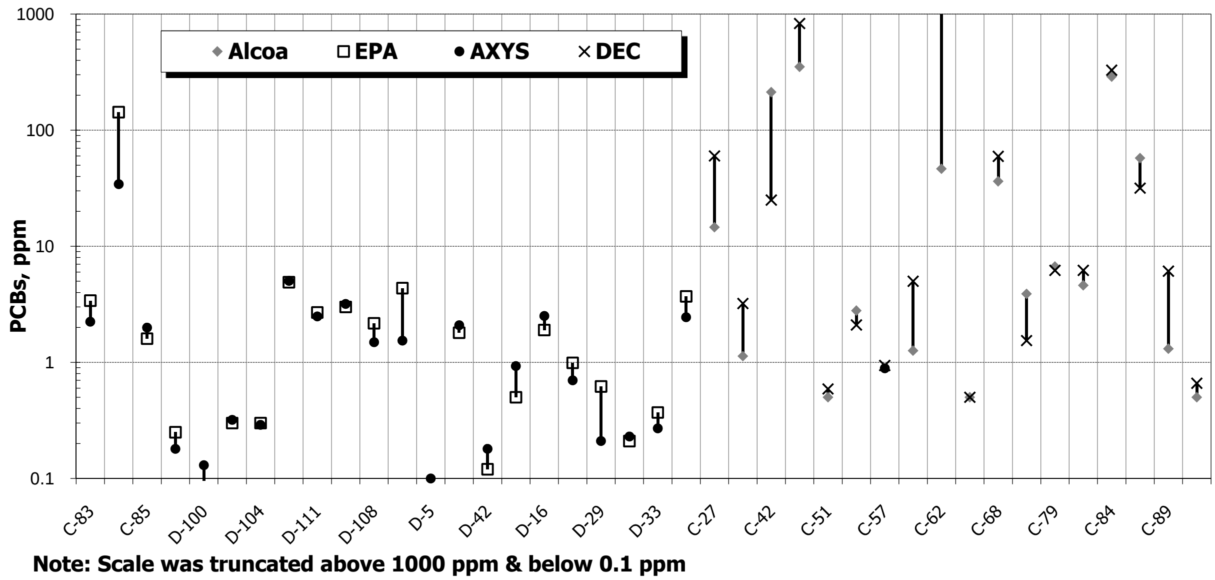


Figure 6-28
PCB Results from Additional Split Samples (Method 8082 & 8270)

As a result of EPA and DEC concerns regarding the variability in split samples from the initial batch of results, sampling crews began devoting additional efforts to homogenizing samples. The success of these efforts may explain the consistency between AXYS and EPA results. These results also suggest that inter-lab variability can be minimized, but it is likely that additional factors beyond sample homogenization must be considered. The poor agreement between the Alcoa lab and DEC results, which are also based on the well-homogenized samples, may be due to analytical variability related to the use of different methods (8082 vs. 8270).

The pace of split sampling continued to accelerate as dredging continued through the fall of 2001. By the end of the project, there were 72 split sample pairs with both EPA and RMC laboratory sampling results based on Method 8082. A graph of these data is shown in Figure 6-29. Additional split samples were collected by EPA but in many cases only immunoassay analyses were conducted by RMC; unless the immunoassay yielded a <1 ppm result, the data were excluded from the graph.

Selected split sample pairs are identified with labels on the chart to illustrate the diversity in results, from more or less identical (C-41 and D-116), to somewhat different (C-23, C-86, and D-130) to significantly different (A-8 and D-67). Although the data appear to vary significantly, the two data sets have an excellent correlation (R=0.99), and are about equally divided regarding which analysis generated the higher result (i.e., the EPA split was just as likely to return a concentration higher than the RMC result as it was to yield a lower concentration).

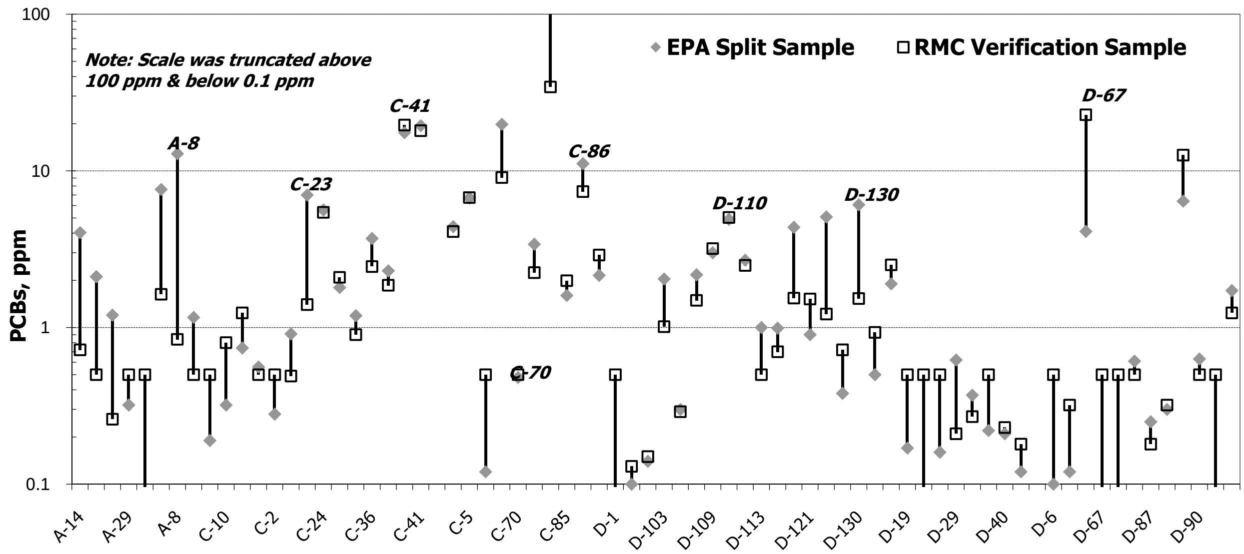


Figure 6-29
RMC – EPA Split Sample Results (Complete Set)

Figure 6-30 presents analytical results from verification samples collected at different times from the same location prior to any additional dredging (analogous to the "resampling" effort described below). All analyses were conducted using Method 8082. The contrast in results reflects both matrix and inter-lab variability. Matrix variability is demonstrated by the contrast in PCB results for samples where the verification sample led to a follow-up core sample, such as occurred at cells D-69 and D-70. Matrix variability is also shown by the contrast in PCB results from samples collected at the same location but at different times and analyzed by the same lab (e.g., D-5, D-33, and D-87). A combination of matrix and inter-lab variability can be seen in PCB results from samples collected from the same location at different times and analyzed by different labs (e.g., D-11, D-69, D-100).

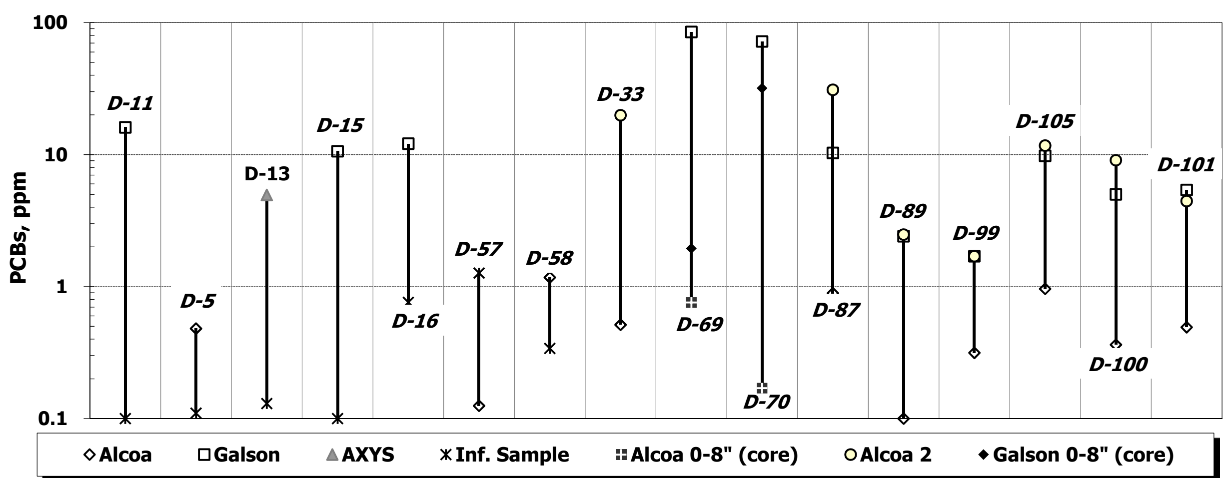


Figure 6-30
PCB Results from Successive Sampling with No Change in Dredging Status

An additional set of data representing samples collected from the same location with no change in dredging status was generated at the end of the dredging program as part of the EPA-directed resampling effort. Results from this activity, which were discussed in detail in previous sections, are shown in Figure 6-31.

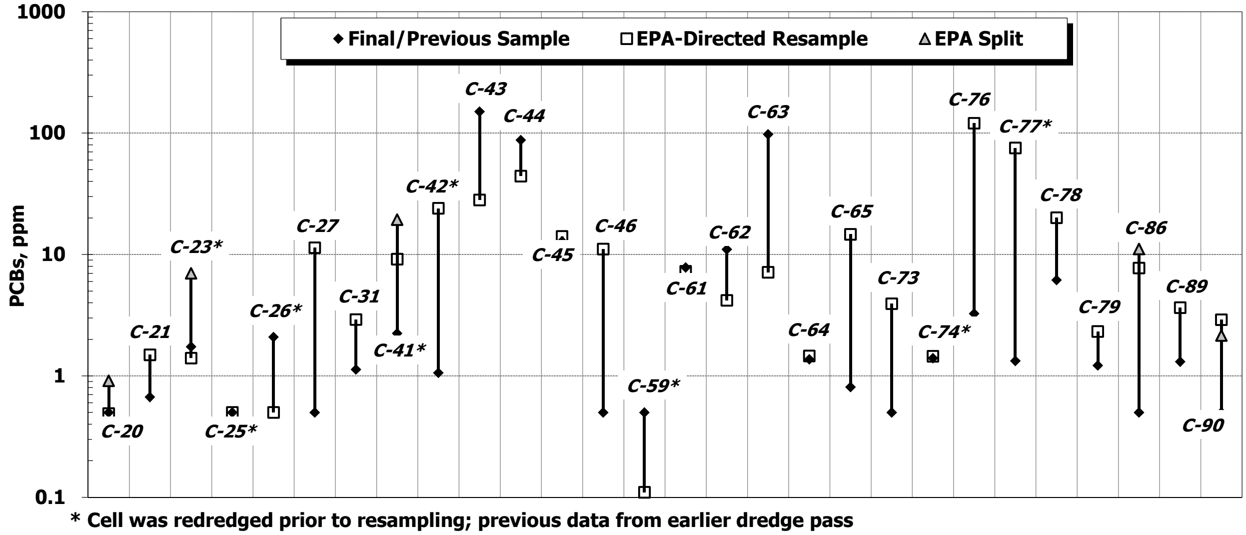


Figure 6-31
EPA-Directed Resampling Effort (No Change in Dredge Status)

A statistical evaluation of the data was also conducted as summarized in Table 6-25. The data have essentially no correlation but an F test of variance ratios indicates that the 2 data sets are samples of the same population (as expected).

Table 6-25
Statistical Summary for PCB Results from EPA-Directed Resampling Effort

Observations	Statistic	Computed	Critical	Conclusion
28	Correlation, *r*	0.15	0.367	No correlation
	Variance Ratio, F	0.602	249	Equal variance (same population)

The variability observed in the resampling results reflects the mixture of bottom conditions, contaminant levels, dredging status, type of dredge bucket used, proximity to areas where alternative dredging methods were used, and other factors. Because of the large number of variables associated with this data set, a detailed point-by-point comparison is not feasible. The data do show, however, that in some cases there was a significant difference in concentrations, in some cases no difference at all, and in others a relatively minor difference. The same pattern was observed with most of the other data sets discussed in this section—further illustrating the inherent variability associated with these sediment data.

The analysis of duplicate samples (co-located field duplicates) provides a useful measure of matrix and analytical variability; however, it can be difficult to distinguish between the two if both are present. Figure 6-32 presents results for PCBs from field duplicate samples – two separate aliquots of material collected at the same location. Most labs will attribute variability in duplicate sample results (from soil or sediment) to heterogeneity in the distribution of contamination in the sample (matrix variability) and/or an improperly homogenized sample. Heterogeneity in the sediment matrix is difficult to overcome even with the most robust of homogenization methods, particularly for contaminants with a propensity for sorption to specific components of the matrix (e.g., native organic matter, clay minerals

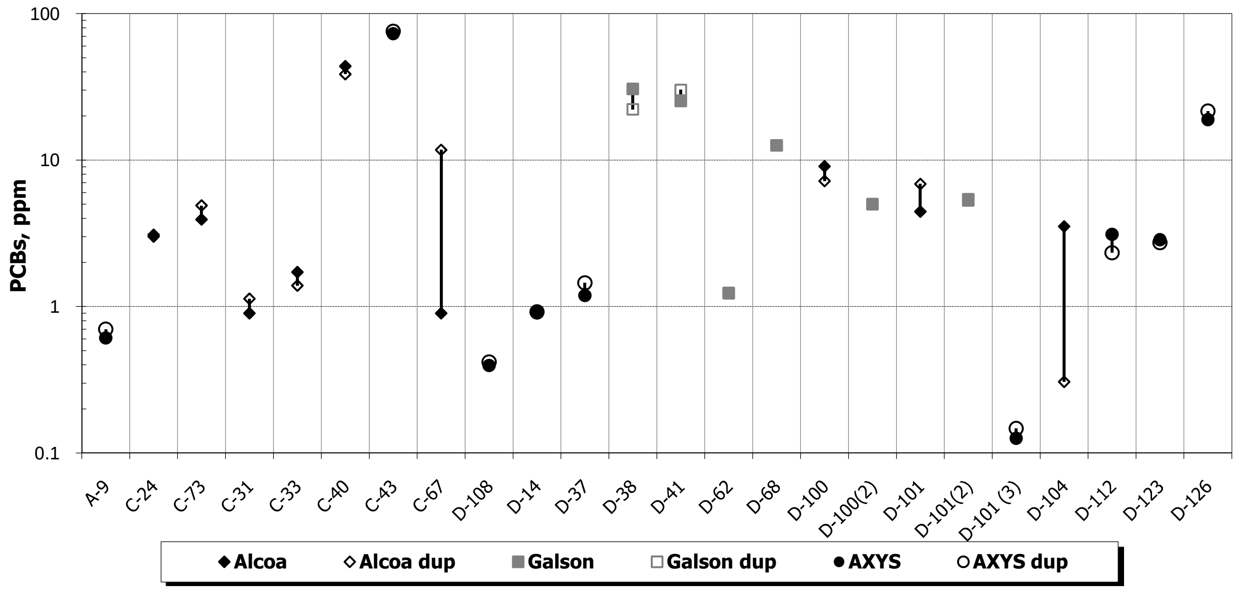


Figure 6-32
Field Duplicate Sample Results for PCBs

An illustration of analytical variability is shown in Figure 6-33, which presents split sample results generated by in-house analyses at the NYSDEC lab in Rensselaerville, NY (these data were transmitted to RMC as preliminary and it is not known if further verification/validation was completed) Each sample was analyzed for PCBs using three separate methods: 8082, 8270, and the Selective Ion Mode (SIM) of 8270. As shown both in the data table and in the chart, significant differences in total PCB concentration were reported using the different methods. Concentrations typically varied by a factor of 2 and in some cases by an order of magnitude or more.

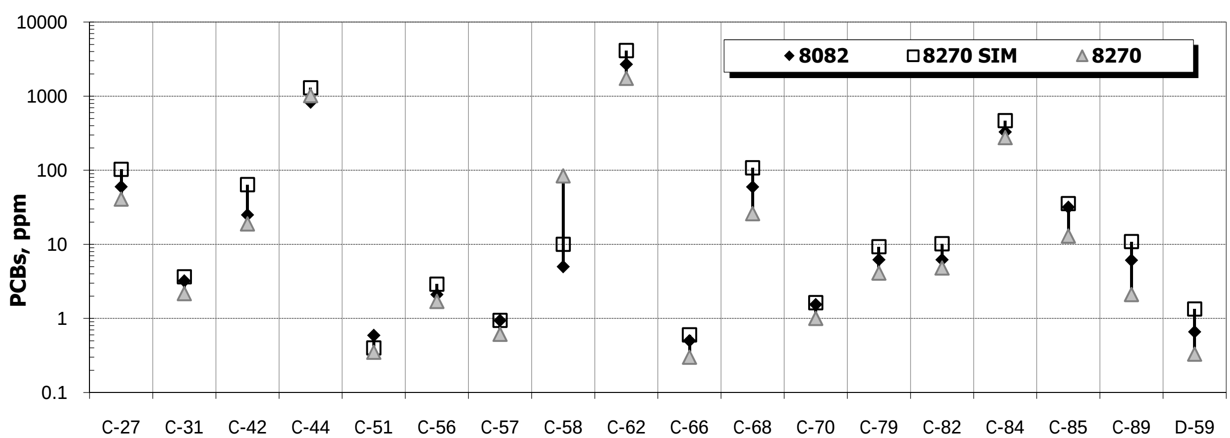


Figure 6-33
Analytical Variability in Sediments Samples Analyzed by NYSDEC Lab

In conclusion, sediment data collected to date show a high degree of variability in PCB concentrations. The variability is present across all potential combinations of laboratories, methods, dredging areas, contamination levels, and the circumstances of the sampling event. RMC had anticipated this variability, which was the basis for the various threshold levels in the flow sheet logic for determining whether remediation requirements had been achieved. From the regulatory perspective, however, this variability introduced uncertainty into the data used to evaluate cleanup verification samples, which led to everincreasing numbers of split samples and requests to resample areas previously shown to be clean. As more and more samples were being split and more and more cells were being resampled, the complexity of the project—and its cost—increased dramatically.

The more times a cell is sampled (with no change in dredging status) or the more times a given sample is divided (split) and analyzed, the greater the chance of obtaining an alternative PCB value—it may be higher, or it may be lower, but it is going to different, by a few percentage points or as much as an order of magnitude or more. If the results from a particular sampling event were not favorable, collection of another sample, or analysis of another aliquot from the same sample jar, provided an excellent opportunity for obtaining a substantially different sampling result, possibly one that was more favorable. The problem with this approach is that there is really no way to select one value as being better or more accurate than the other—assuming the labs are following standard methodologies and the samples are collected in accordance with proper procedures (both of which were true)—the numbers are just different.

Given the variability inherent to the matrix, analytical methods, and laboratories, it is clear that additional sampling and analysis was going to identify different concentrations of PCBs. In the end, however, these additional data did not eliminate the uncertainty associated with sediment PCB analyses. RMC made decisions based on the maximum PCB result obtained from any of the various analyses that were being conducted. The net result was that more sediment was removed from the river, more stockpiled sediment was sent for offsite disposal, and more cells were capped.

6.1.6 Dredging Limitations and Areas Not Amenable to Dredging

The preceding discussion of remediation success based on verification sampling supported that the dredging technology had limits with regard to how effectively it could remove contaminated sediment, and that in a number of specific instances (i.e., dredge cells that could not be remediated to the clean up goals), the limits of the technology had been reached. This section presents an expanded discussion of these issues with regard to the attainment of cleanup goals.

Limitations in Dredging Technology

The results of the St. Lawrence River Remediation project are very consistent with the limitations of dredging technology as identified in a number of publications which have been released since the completion of the 2001 construction activities. These documents include the USEPA Contaminated Sediment Guidance for Hazardous Waste Sites (USEPA, 2005) and the National Research Council Report on Sediment Dredging at Superfund Megasites (NRC, 2007). The EPA-approved *Final Design Report* for the project included provisions for follow-on actions (capping) in the event that cleanup goals could not be achieved.

Dredging Effort

RMC expended a considerable level of effort to achieve cleanup goals and remove as much contaminated sediment as was technically feasible from the river. Figure 6-34 summarizes the overall dredging efforts completed in 2001. Fully half of the dredge cells received two or more passes, and nearly one quarter of the cells received three or more passes. A total of 546 dredge passes were completed, which equates to an average of just over two passes for all 268 dredge cells.

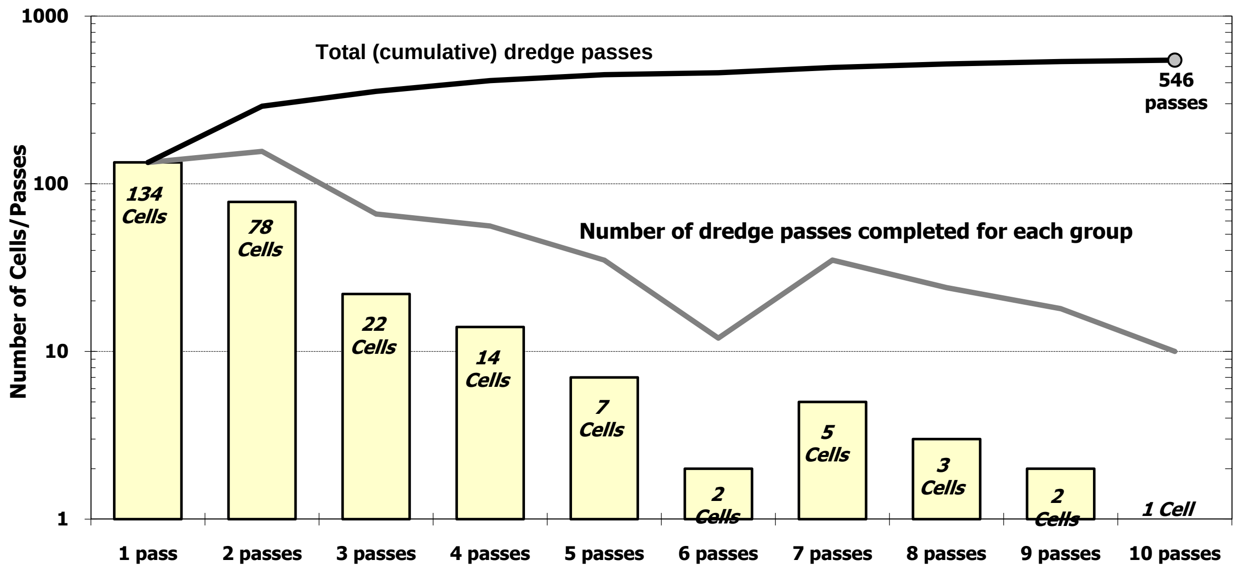


Figure 6-34
Summary of Overall Dredging Effort

Dredging beyond the first pass was based on the results of the verification sampling data, discussed in detail above. In their simplest form, these results could be interpreted three ways: either the cell was clean (<1 ppm PCBs), contamination levels had decreased ("getting better"), or concentrations increased ('getting worse"). Figure 6-35 presents a dredging progress summary based on these three conditions. The determination of getting better or getting worse was based on a comparison of verification sampling results from the dredging pass indicated to that reported for the previous dredge pass. What is not shown is how many "getting better" dredge passes were required to get back to the point before a "getting worse" dredge pass. This concept is illustrated on a number of previously presented progress charts.

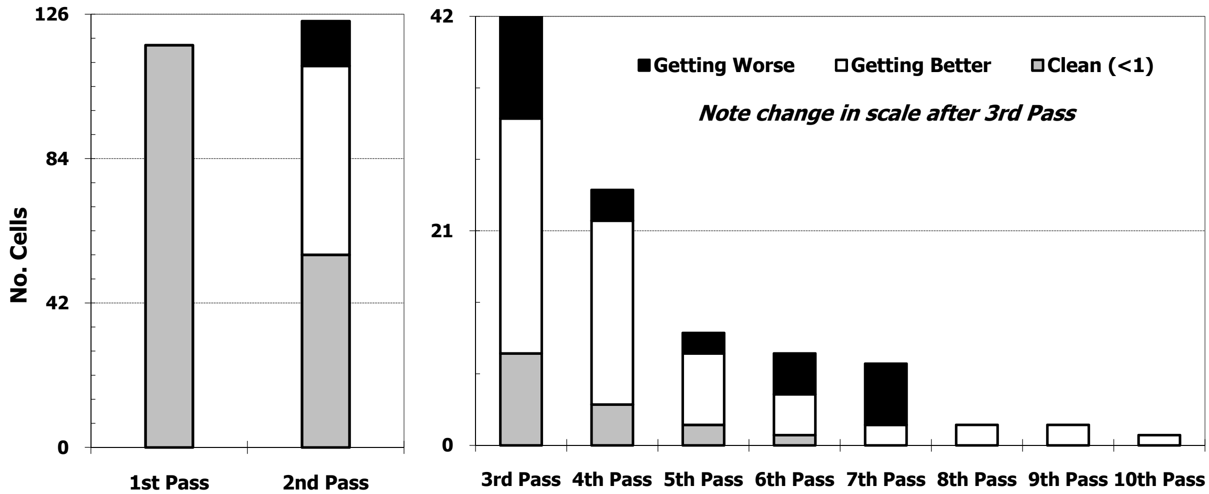


Figure 6-35
Overall Dredging Progress Based on Verification Sampling Results

Flow Sheet Logic

The flow sheet logic was intended to define the level of effort and measurable improvement required in areas that did not meet the cleanup goals after dredging to design depth. For cells where repeated dredging efforts did not attain the cleanup goals, the process was expected to result in these cells being assigned to the category of Mark for Further Evaluation or MFE. As stated in the *Final Design Report*, "additional measures may be taken in specific cells to achieve the criteria (cleanup goals), such as redredging, or individual cells can be designated for capping."

In August of 2001 RMC recognized that variability in the verification sampling results and poor recovery of material from redredging efforts made it unlikely that a number of cells would either be cleaned up or reach the MFE category. As a result, Field Change Request 0027 was prepared and transmitted to EPA on September 5, 2001. This FCR proposed a process for determining that an area was not amenable to dredging, and included a procedure for making this determination (with the concurrence of EPA) as well as a modified flow sheet logic diagram that allowed cells determined to be not amenable to dredging to be categorized as MFE.

Conclusions

Repeated dredge passes were completed in the attempt to achieve cleanup goals but these efforts were not successful in all of the dredge cells. The data generated from the verification sampling support that the technical limits of the dredging technology had been reached in the majority of cells that could not be remediated to the cleanup goals. Contaminated sediment was removed to the maximum extent practicable from these cells, but little benefit was gained from further dredging as these cells were no longer amenable to dredging. These results are consistent with findings from both USEPA (USEPA 2005) and the National Research Council (NRC, 2007) regarding the limitations on dredging effectiveness.

6.2 ATTAINMENT OF DESIGN REQUIREMENTS

The *Final Dredging Program Design Report for the River Remediation Project* (M&E 2000), approved by EPA in June 2000, established the technical basis for the St. Lawrence River Remediation Project. Site remediation work completed in 2001 was conducted in accordance with the design and *Final Dredging Program Work Plan* (Bechtel 2000), which described the scope of activities and how each activity was to be implemented. Deviations from the design or work plan were documented as needed by Field Change Notices, Field Change Requests, and Nonconformance Reports as discussed in Appendix G.

Table 6-26 presents a matrix that identifies the major activities, objectives, and design requirements for the remediation project and Alcoa's evaluation as to whether the as-built structures, operations, or remediation results complied with these requirements.

Table 6-26
Final Design Report Compliance Matrix

Activity or Item	Objective	Design Requirements	Design Basis*	Alcoa's Compliance Evaluation
Sediment storage area	Provide adequate area for the temporary storage of sediment from areas known to have PCB concentrations greater than 50 ppm	Construct an area that will be able to store up to 7000 cy of sediment from Area C, control surface run-on and run-off, and contain leachate and storm water generated which will be collected and treated by the water treatment plant	Section 5.0 Drawings: 05000-100 05000-101 05000-102 08000-100	The 4.6-acre Sediment Storage Area (SSA) was constructed in accordance with design specifications and functioned as planned for (1) the temporary storage (stockpiling), dewatering, and load-out of sediment for offsite disposal; (2) truck washing and decontamination activities; and (3) water management (retention basins, run-on/run-off controls, etc.)
Debris/Oversize Washing	Provide an area for high-pressure washing of debris and oversize material that has been segregated out from sediment., to allow for cleaning, sorting and routing of these materials for eventual disposal	Utilize existing facilities for washing of oversize material and debris; Washing to be conducted using hand-held high pressure water spray wands; washing will be performed until material is visually judged to be clean. Cleaned debris will be sent to the onsite landfill or sent offsite for disposal; cleaned rocks will be sent to the onsite quarry	Section 6.0 Performance criteria identified in 6.4.2	Existing facilities were used for this activity; no new construction or significant modifications of these facilities were required. A smaller quantity of oversize material (primarily rocks & boulders) was generated than expected, however, the materials which were generated were successfully decontaminated and disposed of onsite (quarry).
East Dock & Access Road	Provide an unloading point for the sediments dredged from the river bottom, and the transfer of these sediment and oversize material to the staging areas by trucks	Construct a fixed concrete and sheet piled structure (East Dock) in accordance with design drawings and specifications. A second, floating structure, was to be used as a platform for the unloading crane and to provide a parallel surface for fleeting of barges. The dock will be constructed to contain liquids from material barge unloading operations, truck washing and storm water. Water will be collected in a sump for transfer to wastewater retention basins in the SSA.	Section 7.0 Drawings: 07000-100 07000-101 07000-102 07200-100-R3	The East Dock was constructed in accordance with design specifications and functioned as planned for the offloading of dredged sediment from material barges. Water management systems also functioned as designed. FCN 00018 for the East Dock extension identified a change from the planned floating structure to an engineered extension to the dock based on equipment to be used and safety considerations. The constructed East Dock Extension, comprised of a steel framework on driven H-beam piles with timber decking, functioned as designed for the unloading of material barges.
Sheet Pile Laydown Area, Access Road, & West Dock	Provide adequate storage space in the sheet pile laydown area and facilitate transport of sheets and king piles and bracing to West Dock	Laydown area, access road and dock were previously constructed. Maintenance and minor upgrades will be accomplished as needed	Section 4.0	These existing facilities were used as planned in the storage, transport, and loading/unloading of materials and equipment.
Water Treatment Plant	Provide for treatment of spent wash water, drainage from sediments, rock washing, and stormwater run-off from the SSA and East Dock	Construct and operate treatment plant to handle 150 gpm in continuous or batch modes; treat as necessary to meet NYSDEC discharge criteria. Plant was procured from a vendor who fabricated components, assisted in the set-up, and developed an Operations (Ops) Manual.	Section 9.0 Drawing: 09000-100 Vendor submittals, incl. Ops Manual	The water treatment plant was fabricated and installed at the site in accordance with the specifications in the design and bid package. During initial operations, an exceedances in the pH discharge limit occurred (NCR-002) and during routine operations additional concerns were identified due to high solids loading of the influent stream. Operational procedures and management controls were revised and put into place, resulting in compliance with all discharge, monitoring and reporting requirements.
Sheet Pile Wall	Construct an effective barrier to limit the effects of dredging on the St. Lawrence River and downstream objectives	Install king piles, sheet piles and bracing in accordance with the *Final Dredging Design Report – Braced Sheet Pile Design*	Section 2.0 Drawings: 02000-101-R2 02000-102-R2 02000-103-R3 02000-104-R2 02000-105-R2 02000-106-R2 02000-107-R2 02000-108-R2 02000-209-R3 02000-210-R4 02000-211-R4	The sheet pile was constructed was constructed between April 5 and June 4, 2001. Installation was in accordance with the design; however, bottom conditions complicated the driving of both king and sheet piles, resulting in some offset locations for king piles, use of shorter king piles, need for additional bracing of sheeting where target penetration depths could not be achieved, etc. Differential GPS surveys confirmed the wall was constructed along the proper alignment and a post-construction video survey confirmed the integrity of the bottom seal (and identified 2 holes that were patched).
Silt Curtains	Partitioning of sub-areas within the enclosed remediation area to act as secondary barriers to control turbidity and minimize the transport of resuspended sediment	Erect a silt curtain to enclose Area C and isolate the clean portion of Area B Silt curtains will be free-floating and adjusted to rest on the bottom, anchored every 100 ft. Silt curtains were procured from a vendor who fabricated components and assisted in the deployment of the curtains.	Section 3.4.2.3 Drawings 03000-201-R4 03000-202-R4 03000-203-R0 Vendor submittals	Silt curtains were fabricated in accordance with the design and specifications of the bid package. The curtains were successfully deployed and maintained as required during dredging operations. Turbidity monitoring data indicate the curtains functioned as designed in the isolation of subareas within the remediation area.
Air Gates	Air curtains will be used as gates with silt curtains to prevent turbidity from escaping Area C and from entering Area B during material barge transport;	Install air curtains across openings in silt curtain wall surrounding Area C (2 gates) and between the Area B silt curtain and sheet pile wall. Air gates were procured from a vendor who fabricated components and assisted in their installation.	Section 3.4.2.3 Drawings: 00002-11931-R1 03000-201-R4 03000-202-R4 03000-203-R0	Air gates were constructed in accordance with the vendor's design and installed and operated as required. Operation of the air gates was conducted on a 24-hour basis throughout the dredging activities and functioned as required in creating a vertical barrier across an opening in the silt curtains (or between silt curtain and sheet pile wall) without impeding boat traffic.

Table 6-26 (cont.)

Activity or Item	Objective	Design Requirements	Design Basis*	Alcoa's Compliance Evaluation
Vegetation Suppression	Eliminate aquatic vegetation in areas to be dredged to minimize sediment handling problems.	Obtain NYSDEC permit and apply aquatic herbicide under the supervision of licensed pesticide applicator; notification will be provided to downstream users of river water.	Section 3.4.3 NYSDEC Permit No. 6-A14-01 Vendor submittals	Herbicide *Reward*® applied 6/8/01 in accordance with NYSDEC Permit by Burden Aquatics, Reg. No. 11305; Applicator Certification No. C4808008. NYSDEC monitored application & collected downstream water samples from river; 100-ft opening in sheet pile wall was closed prior to application.
Sediment Removal	Remove contaminated sediments containing PCB concentrations >1 ppm, total PAH concentrations >10 ppm, and total dibenzofuran concentrations >1 ppb.	Remove sediments using the Cable Arm environmental bucket and WINOPS dredge positioning software, differential GPS, and pressure transducers to record *X*, *Y*, and *Z* positions for each bucket cut. Procedures for dredging operations, including non-closure of bucket and contingency dredging around obstructions are identified.	Section 3.4.4 Drawings: 03000-102-R11 Contingency Plan (*RAWP*) Marine Tech Ops Manual	Approximately 86,000 cy of wet sediment and 20,200 lbs of PCBs were removed using a combination of dredging methods as described in Section 3. Dredging operations were more complicated than expected, both from an operational and performance perspective. Cleanup goals were not attained in several cells as the limits of the dredging technology (given site conditions) were reached.
Removal Verification	Verify that all sediment with contamination above the cleanup goals has been removed, that additional dredging is needed, or that contamination has been removed to the greatest degree practicable	*Flow Sheet Logic* defines the level of effort & measurable improvement required to continue dredging in areas that do not meet cleanup goals after dredging to design depths. Steps to be taken are based on sampling results: • PCBs >50 ppm: cell will be core sampled to establish new dredging design depth. • PCBs <50 ppm but >10 ppm: cell will be redredged until cleanup goals are achieved or no measurable improvement is obtained, but at a minimum the cell will be redredged twice if cleanup goals are not achieved or there is no measurable improvement. • PCBs <10 ppm: the cell will be dredged until cleanup goals are achieved or no measurable improvement is obtained.	Section 3.4.4.2 Figure 3-8, *Flow Sheet Logic for Areas Amenable to Dredging,* in Final Design Report	Sediment verification samples were collected and analyzed in accordance with the design requirements; analytical data were used to guide follow-on decisions regarding the need for additional dredging or whether remediation requirements were complete. Complexities related to the heterogeneous distribution of contaminants in the sediment, variability in the sediment analytical data, and the performance limits of the dredging technology resulted in a much less predictable process of contaminant reduction via continued dredging. For this reason, the Flow Sheet Logic could not be followed in all cells and the final status of a number of cells was not resolved at the conclusion of the dredging process. Additional discussion is presented in Section 6.1.6.
Sediment Dewatering	Allow for the drainage of free water from the material barges while dredging is underway & prior to unloading.	Construct sand filter system on barges to all drainage from the material barges to be filtered through a sand media before flowing back into the river.	Section 3.4.5 Figure 3-9 in Final Design Report	Discharge was monitored in accordance with RAWP, EMP. Sand was changed out whenever flow was impeded or turbidity was observed in discharge.
Sediment Unloading	Allow for the transfer of dredged sediment from the material barges to trucks for onsite transport to the SSA or on-site landfill.	Material will be unloaded using Cable Arm bucket and transferred to hopper of sediment processing system for scalping of +6" material. Material <6" will pass through screen into trucks for transport to SSA or landfill. Trucks will be washed prior to leaving East Dock.	Section 3.4.6 Figure 3-10 in Final Design Report	Grizzly set up on East Dock was not used due to consistency of sediment (wet) and less oversize material than originally expected. A second unloading operation was added to east side of dock to expedite unloading of material barges. All other components were as described in Final Design.
Shoreline Remediation	Remove potentially contaminated soil or sediment along a portion of the Area C shoreline	Remove the upper 1 ft of soil or sediment between elevation 156 and 158 MSL along a 625 ft stretch of shoreline between W7865 and W8485. Upon completion the shoreline will be covered with stone to prevent erosion.	Section 3.5	Shoreline remediation was accomplished using a hydraulic excavator. The limits of the excavation were surveyed prior to the start of digging and the area was restored as stated in the design.
Sediment Processing/ Handling	Prepare the dredged material for transport and disposal or treatment. Provide for gravity drainage of interstitial water and the option to solidify if necessary Incorporate measures to minimize or contain spillage of material, rock, debris and water, thereby preventing the escape of potential contaminants into the surrounding environment.	Preparation of the SSA was addressed above. This section of the design addresses procedures to be followed for the following: • Transport of dredged material to onsite landfill (<50 ppm), SSA (>50 ppm), and interim staging area (>500 ppm) • Containment/dewatering of staged material • Solidification of the material if needed • Load-out of the >50 ppm material for transport to offsite disposal facility • Staging of the >500 ppm material • Collection/Processing of Interstitial Water	Section 8.0 Drawings: 08000-100	Sediment processing was conducted in accordance with design requirements. The only notable deviation from the design pertained to the >500 ppm material, which was treated on-site and sent for offsite disposal in accordance with applicable EPA and NYSDEC regulations. Sediment stockpiling, characterization sampling, temporary storage, dewatering, stabilization, and load-out for transport to offsite disposal facilities was accomplished in accordance with the design and applicable procedures.
Removal of sheet pile wall	Remove the sheet pile wall at the conclusion of the remediation activities.	Sheeting, king piles, wales and bracing will be removed using the same equipment and methods that were used for installation.	Section 3.4.2	Sheet pile wall was removed as designed. All materials were staged on-shore in the SSA for decontamination prior to transfer to the Sheetpile Laydown Area for eventual shipment offsite.

* Sections identified under design basis correspond to sections in the *Final Dredging Program Design Report, Revision 3*, May 2000.

6.3 COMPLIANCE WITH EMP ACTION LEVELS

Table 6-27 presents an overview of the monitoring program, specifically the monitoring objective, activity, and action levels, and includes a summary of the findings with regard to compliance with the action levels.

The extensive monitoring program conducted for the 2001 remediation activities did not identify any significant environmental impacts from the dredging, sediment handling, offsite shipment, or on-site disposal activities. There were isolated exceedances of action levels but these were infrequent and/or localized in impact. The remediation had no measurable impact on water quality in the St. Lawrence River or air quality at the site boundary. Worker protection was verified through extensive industrial hygiene monitoring. Additional details are provided in Section 4.

6.4 COMPLIANCE WITH ROD REQUIREMENTS

Table 6-28 summarizes the major components of the ROD and ROD Amendment and Alcoa's evaluation of how each element was addressed in the planning and implementation of the 2001 St. Lawrence River Remediation Project construction activities.

Table 6-27
Compliance with Environmental Monitoring Action Levels

Monitoring Objective	Monitoring Activity	Parameter	Action Level	Basis of Action Level	# Samples Collected	# Exceed-ances	Compliance Summary
Water Quality	Water Column in St. Lawrence River	PCBs	2 µg/L	EMP	885	0	No exceedances of PCB or PCDF action levels. PAH exceedances were localized occurrences with no impact on river.
		PAHs	0.2 µg/L		152	3	
		PCDFs	PQL		150	0	
	Water Intake Monitoring	PCBs	2 µg/L	EMP	261	0	All water intake sampling results were below action levels.
		PAHs	0.2 µg/L		117	0	
	Water Treatment Plant Effluent	PCBs	0.3 µg/L	EMP	24	0	An exceedance for pH (9.1) during start-up operations. Corrective measures were taken that eliminated problem.
		TSS	10 mg/L		24	0	
		Oil & Grease	15 mg/L		24	0	
		pH	6 – 9 pH	DEC permit	75	1	
	Turbidity in St. Lawrence River	Turbidity	25 NTU > bkgrnd	EMP	>7,000	0	No exceedances in the St. Lawrence River
Air Quality	Boundary air monitoring	PCBs	0.1 µg/m^3	EMP	482	58	Exceedance of PCB action levels at SSA and Interim Storage Pad stations. No exceedances at RMC property boundary .
		PM_{10}	150 µg/m3 > bkgrnd	EMP	476	0	
	Area monitoring	PCBs	1 µg/m^3	OSHA PELs	290	0	No exceedances
		PAHs	200 µg/m^3		134	0	
	Personnel air sampling	PCBs	1 µg/m^3	OSHA PELs	43	0	No exceedances
		PAHs	200 µg/m^3		6	0	
	Ambient dust	Dust	150 µg/m^3 > bkgrnd	DEC TAGM #4031	2,473	5 (est.)	Initial, localized problems during sediment stabilization activities involving Portland cement; no offsite impacts: corrective measures were taken eliminated problem.
Sediment Remediation & Disposal	Sediment cleanup goals	PCBs	1 ppm	1993 ROD	268	57	13 cells w/ 2-5 ppm; 44 cells with 1-2 ppm; see Section 6.1.1
		PAHs	10 ppm		96	26	26 cells >10 ppm; see Section 6.1.2
		PCDFs	1 ppb		32	0	No exceedance of cleanup goal
	Waste characterization (disposal)	PCBs	<50 ppm 50 – 500 ppm >500 ppm	1998 ROD Amendment	71	0	All sediment dredged from Area C or form cells with verification samples >50 ppm was characterized and disposed of in accordance with the ROD & regulatory requirements.

Table 6-28
Alcoa's Evaluation of Attainment of ROD Requirements

Remedy Component	Requirement	Compliance Determination
1993 ROD		
Dredging/Excavation of Contaminated Sediments [Page 28-29, Section IX, Selected Remedy]	Sediments in the St. Lawrence River with PCB levels above 1 ppm, PAH levels above 10 ppm, and TDBF (PCDF) levels above 1ppb will be dredged and/or excavated.	Contaminated sediment was removed to the maximum extent practicable, accomplishing a near 99% reduction in PCB concentrations across the site. Technical constraints on the effectiveness of dredging precluded the attainment of PCB and PAH cleanup goals in all cells.
	The Area to be dredged is shown in figure 11.	The final dimensions of the remediation area were determined during the design phase and approved by EPA in the Final Design Report.
	EPA estimates that approximately 51,500 cy of sediment will be removed.	This original estimate was superseded by a revised estimate presented in the 1998 ROD Amendment (see below).
	All contaminated sediments in the area to be dredged will be removed given the technological limitations associated with dredging.	The remediation area, consisting of 268 dredge cells, was dredged to the maximum extent practicable given the technological limitations of the dredging technology (see Section 6.1).
	Prior to dredging, additional sediment and surface water sampling will be conducted to better delineate the extent of the area to be dredged and to serve as baseline monitoring data.	RMC conducted several episodes of additional sampling to better delineate the remediation area. The final dimensions of the remediation area were specified in the Final Design Report.
	Bathymetry in the Reynolds Study Area will be refined and remapped.	Bathymetric surveys were completed in 1993 and the remediation area was mapped in detail. Additional bathymetric studies were completed in 2001 prior to the start of dredging to aid in navigation.
	Areas of dense vegetation and any areas containing boulders or debris will be identified and mapped.	Video transects and geotechnical sampling were conducted to identify bottom conditions. Areas of vegetation mapped originally by Woodward Clyde were confirmed prior to the aquatic herbicide application in June 2001.
	The initial dredging program will be conducted in a manner which will identify site-specific information and operating parameters such as dredging rates and depths, sediment removal efficiencies, silt curtains and sheet piling effectiveness, sediment dewatering methods, and sediment suspension and settling characteristics. This information will be evaluated and used as appropriate in modifying operating procedures to improve the effectiveness of the removal program.	EPA and RMC agreed in 1995 to eliminate the initial dredging program; this agreement was documented in the *Final Dredging Program Work Plan,, Rev. 1* (Nov. 1995). At a meeting in April 1996 with EPA, RMC agreed to evaluate dredging performance in a portion of Area A, as documented in the *Area A Operations Plan*, submitted in July 1996. This plan was eventually abandoned after a meeting with EPA in the spring of 1999, as documented in the *Final Dredging Program Work, Rev. 3* (May 2000)

Table 6-28 (cont.)

Remedy Component	Requirement	Compliance Determination
1993 ROD (cont.)		
Dredging/Excavation of Contaminated Sediments (cont.) [Page 28-29, Section IX, Selected Remedy]	*Silt curtains and, if deemed necessary during design, sheet piling will be installed on the river side of the areas to be dredged to provide a stilling basin for dredging operations and to minimize transport of contaminated sediment which may be resuspended during the dredging process.*	Sheet piling and silt curtains were installed in accordance with the *Final Design Report* and *Final Dredging Program Work Plan*.
	Sediments will be generally removed using hydraulic dredges but mechanical dredges may also be used when appropriate.	A specialized environmental clamshell bucket from Cable Arm was used to remove the bulk of the sediments. Hydraulic dredging was not used due to water management concerns.
	Sediments near the shoreline may also be excavated using conventional excavation equipment.	Excavation from the shoreline was conducted for selected cells in Area C using conventional excavation equipment.
	During dredging, sediments and surface water will be monitored to ensure that downstream transport of contaminated sediment is minimized.	An extensive environmental monitoring program was conducted in accordance with the EPA-approved *Environmental Monitoring Plan*.
	A contingency plan will be developed which describes measures to control and/or minimize the impacts of dredging. Measures to control the impacts of dredging could include, if approved by EPA, modification and/or suspension of dredging activities.	The *Remedial Action Work Plan, Rev. 1* included a *Contingency Plan* that identified measures to control and/or minimize the impacts of dredging. EPA approved the *Contingency Plan* in June 2001.
	Oversize materials will be screened from the dredged sediments as the sediments are transported to the shoreline.	Initial attempts to screen oversize materials from the sediment were conducted on the East Dock. Due to smaller than expected quantities of oversize material and the higher than expected moisture content of the sediment, attempts to screen oversize material were terminated with the concurrence of the on-site EPA representatives.
	All water that is removed from sediments or generated during the treatment process will be discharged to the St. Lawrence River in compliance with substantive SPDES requirements.	NYSDEC issued a permit for Water Treatment Plant Discharges. Sampling and reporting was conducted in accordance with NYSDEC SPDES requirements.
	Dredged/excavated areas will be restored to their initial grade either through the use of fill, or if determined to be appropriate by EPA during design, through natural sediment deposition.	Per the EPA-approved *Final Design Report*, restoration of dredged areas will be through natural sediment deposition. An assessment of post-dredging bottom conditions was conducted subsequent to the 2001 river work.

Table 6-28 (cont.)

Remedy Component	Requirement	Compliance Determination
1993 ROD (cont.)		
Partial Thermal Desorption of Sediments [Page 29, Section IX, Selected Remedy]	Superseded by 1998 ROD Amendment	Not applicable.
Sediment Disposal in Black Mud Pond [Page 29-30, Section IX, Selected Remedy]	Superseded by 1998 ROD Amendment	Not applicable.
Floodplain/Wetlands [Page 30, Section IX, Selected Remedy]	*Prior to remediation, a floodplains assessment will be performed and a determination will be made as to the consistency of the remedial action with the New York State Coastal Zone Management Program.*	A floodplains assessment was performed as documented in the Final Dredging Program Work Plan; no significant impact on the floodplain was identified. The remedial action as implemented was determined to be consistent with the New York State Coastal Zone Management Program; the U.S. Army Corps of Engineers (COE) did not require a permit for the dredging, which triggers coastal zone management requirements. Representatives of the COE and NYSDEC conducted oversight of the project.
1998 ROD Amendment		
On-site Thermal Treatment [Page 16, Section VII, Selected Remedy]	*Eliminate on-site thermal desorption treatment*	On-site thermal treatment was not conducted.
Disposal of Dredged Materials [Page 16-17, Section VII, Selected Remedy]	*All dredged and dewatered sediments with PCB concentrations exceeding 500 ppm will be transported offsite for treatment at a TSCA-approved facility*	Treatment was conducted onsite and material was disposed of in accordance with all applicable State and Federal regulatory requirements.
	All dredged and dewatered sediments with PCB concentrations between 50 and 500 ppm will be transported off-site to a TSCA-approved landfill.	Sediment dredged from Area C and other cells shown through post-dredging verification sampling to have ≥50 ppm PCBs were stockpiled and characterized in accordance with the EMP. All materials shown to have ≥50 ppm PCBs through this sampling were transported off-site for disposal at Model City, a TSCA-approved landfill near Buffalo, New York.
	All dredged and dewatered sediments with PCB concentrations less than 50 ppm will be disposed of on the existing Industrial Landfill located at the Reynolds Facility.	Sediment dredged from cells shown through pre-dredging characterization or post-dredging verification sampling to have <50 ppm PCBs was disposed of in the on-site Industrial Landfill at the RMC facility.

Table 6-28 (cont.)

Remedy Component	Requirement	Compliance Determination
1998 ROD Amendment (cont.)		
Closure of On-site Landfill [Page 17, Section VII, Selected Remedy]	*Following placement of the sediments in the Industrial landfill, it will be capped in accordance with NYSDEC's 1992 ROD (as amended in June 1995) for the land-based remedy.*	Capping and closure of the landfill was conducted in 2002 in accordance with all NYSDEC requirements.
Disposition of Dredged Materials [Page 17, Section VII, Selected Remedy]	*Following the dredging and dewatering of sediments, verification sampling will be performed to delineate which portion of the dredged materials will be sent off-site for landfilling or treatment and which portion will be landfilled on-site.*	Per the Final Design Report and EMP, dredged materials from Area C and other cells shown through post-dredging verification sampling to have ≥50 ppm PCBs were stockpiled and characterized through composite sampling as described in REP-014, *Procedures for Collecting Composite Samples of Dredged Sediment*. All materials shown to have ≥50 ppm PCBs through this sampling were stabilized on-site with Portland cement and transported off-site for disposal at Model City. Materials shown to have <50 ppm through this sampling were stabilized and landfilled on-site.
Dredging Scope/ Performance [Page 17, Section VII, Selected Remedy]	*The technological limitations of dredging may preclude the attainment of the cleanup goals established for the St. Lawrence River sediments. If, after the implementation of the dredging project, the EPA determines that the cleanup goals cannot be achieved by existing dredging technologies, the EPA will make a determination at that time whether other remedial action (e.g., capping the remaining contaminated sediments in place) will be performed.*	As described in Section 6.1, cleanup goals could not be attained in all of the dredge cells. In accordance with the process defined in the EPA-approved Final Design Report, dredge cells with >10 ppm PCBs were covered with an interim gravel cap at the end of the 2001 construction season. Subsequent investigative and remedial actions are summarized in Volume 2 of this report.
	All other components of the original remedy will remain the same.	The components of the original remedy were implemented as described above.
Volume Estimates [Page 5, Section IV, Reasons for Issuing the Decision Document Amendment and Page 8, Section V, Description of Alternatives]	*The current (1998) sediment volume estimate is approximately 77,600 yd3.*	The actual quantity of sediment removed from the river was 85,660 yd^3 (wet sediment volume).
	It is estimated that an additional 43,400 yd3 of St. Lawrence River sediment will be consolidated therein (in the Industrial Landfill).	The actual quantity of sediment placed in the on-site landfill was 50,300 yd^3 (in-place volume, after stabilization, placement, and compaction).

6.5 REMAINING WORK SCOPE

Activities conducted subsequent to the 2001 river construction activities are documented in Volume 2 of this report.

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